PI AD-01-39A

TRAINING MANUAL

MB-339A

aircraft

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AERMACCHI
Technical Publications Department

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Page No.	Change No.	Page No.	Change No.
Title	0	14A-12 blank	0
A	0	14B-1 thru 14B-10	0
i thru iv	0	14C-1 thru 14C-21	0
1-1 thru 1-7	0	14C-22 blank	0
1-8 blank	0	14D-1 thru 14D-12	0
2-1 thru 2-8	0	Gloss. 1 thru Gloss. 16.	0
3-1 thru 3-4	0		
4-1 thru 4-10	0		
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7-1 thru 7-32	0		
8-1 thru 8-33	0		
8-34 blank	0		
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10-1	0		
10-2 blank	0		
10A-1 thru 10A-28	0		
10B-1 thru 10B-26	0		
10C-1 thru 10C-14	0		
11-1 thru 11-59	0		
11-60 blank	0		
12-1 thru 12-52	0		
13-1 thru 13-7	0		
13-8 blank	0		
14-1	0		
14-2 blank	0		
14A-1 thru 14A-11	0		

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TABLE OF CONTENTS

Part/Chapter		Page
PRELIMINARY INFORMATION		ii
PART ONE - INTRODUCTION		
Chapter I	Introduction, General Instructions and Restrictions	1-1
Chapter II	Flight Characteristics	2-1
Chapter III	Pre-Flight and Post-Flight Procedures	3-1
PART TWO - VISUAL FLIGHT		
Chapter IV	Ground Operations	4-1
Chapter V	Take-off, Climb and Level Off	5-1
Chapter VI	Visual Flight Non Acrobatic	6-1
Chapter VII	Descent from High Altitude - Approaches and Landings	7-1
Chapter VIII	Aerobatics	8-1
Chapter IX	Emergencies and Simulated Emergencies	9-1
PART THREE - INSTRUMENT FLYING		
Chapter X	Basic Instrument Flying	10-1
Chapter XI	Basic Navigation	11-1
PART FOUR - OPERATIONAL TRAINING		
Chapter XII	Formation Flying	12-1
Chapter XIII	Night Flying	13-1
Chapter XIV	Firing Training	14-1
GLOSSARY		Glos. 1

PRELIMINARY INFORMATION

PREMISE

a. This Manual is applicable to basic and advanced training in the MB-339A aircraft at the Air Force Flying Schools, in accordance with the procedures, directives and training programmes issued or approved by the School Headquarters.

b. During the training flights, the aircraft must always be flown in accordance, or at least not in contrast, with the prescriptions of the following:

(1) Flight Manual PI 1T-MB339A-1

(2) Performance Data PI 1T-MB339A-1-1

(3) Basic Weight Check List and Loading Data PI 1T-MB339A-5

(4) Weapon Delivery Manual PI 1T-MB339A-34-1-1 and PI 1T-MB339A--34-1-2

(5) Applicable checklists.

PURPOSE

The purpose of this manual is:

a. to provide pilots and student pilots with the information required to perform training flights in accordance with the procedures and techniques defined in the training programmes.

b. to provide flight instructors with a complete and detailed didactical aid for the preparation on the ground of training missions.

SCOPE

This Manual contains the instructions and procedures for use of the aircraft throughout the training cycle: it is not and is not intended to be a directive nor a collection of procedures but a guide and a reference book to facilitate and simplify the task of the people assigned to the preparation and performance of the programmes for pilot's basic and advanced training.

CORRECT EVALUATION

Although this manual can serve as a guide in most circumstances, it is not a substitute for sound judgment and pilot's experience. Some cases (such as the presence of emergency conditions, exceptional meteo or visibility conditions, etc.) may require deviation from the procedures described herein.

HOW TO BE ASSURED OF HAVING LATEST DATA

This Manual will be updated only when required, by replacing and adding pages.
The "List of Effective Pages" placed immediately after the title page, allows the currency status of the publication to be checked.

The application of superseded and no more valid procedures may cause dangerous flight conditions.
Therefore, prior to using the manual, make sure that it is updated by inclusion of the latest data.

ARRANGEMENT

The Training Manual is divided into 14 Chapters and comprises an alphabetical index of paragraphs which allows quick location of the subjects treated in the Manual.

CHANGE SYMBOLS

The change symbol consisting of a black vertical line indicates text and tabular illustration changes introduced by an amendment.
Changes to illustrations (except tabular and plotted illustrations) are indicated by a changed area box located in the upper side of the illustration. The box is divided into eight equal parts which represent eight proportional areas of the illustration. The shaded area of the box represents the area of the illustration which contains a change.
The word "NEW" will appear in the box for new illustrations.

WARNINGS, CAUTIONS AND NOTES

The following definitions apply to warnings, cautions and notes found throughout the manual.

WARNING: An operating procedure, practice, etc. which, if not correctly followed, could result in personal injury or loss of life.

CAUTION: An operating procedure, practice, etc. which, if not strictly observed, could result in damage to, or destruction of equipment.

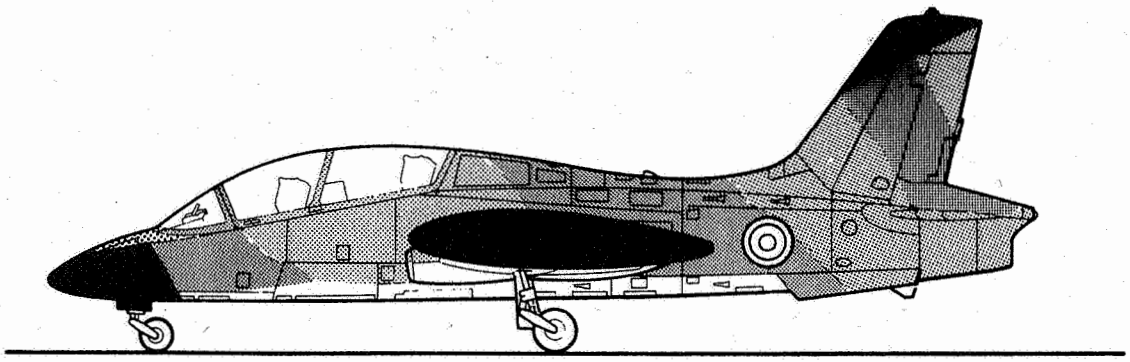
NOTE: An operating procedure, condition, etc. which it is essential to highlight.

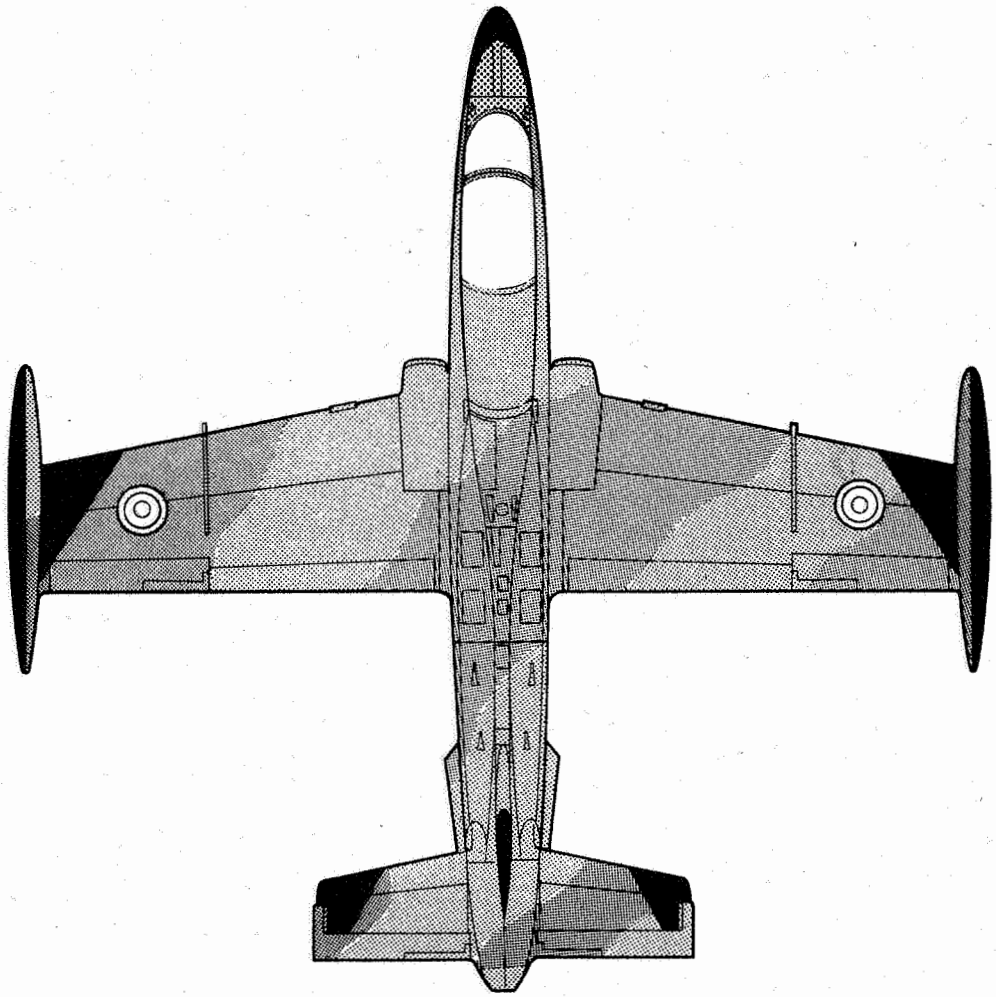
COMMENTS AND RECOMMENDED CHANGES

The Training Manual is maintained current by a constant review of the causes of accidents and flight procedures and by frequent conferences with operating personnel.
For the Manual to be usefully amended, comments, corrections and change proposals from all personnel are however invited.
These should be forwarded on Form 22 "Publication Defect Report" directly to Aermacchi S.p.A. -Via S. Sanvito, 80 - VARESE - Italy.

PUBLICATION DATE

The date appearing on the title page of this manual represents the currency of the material in the manual.
(The manual date is not the printing or distribution date). When referring to the manual, use the basic date plus the date of the latest change.





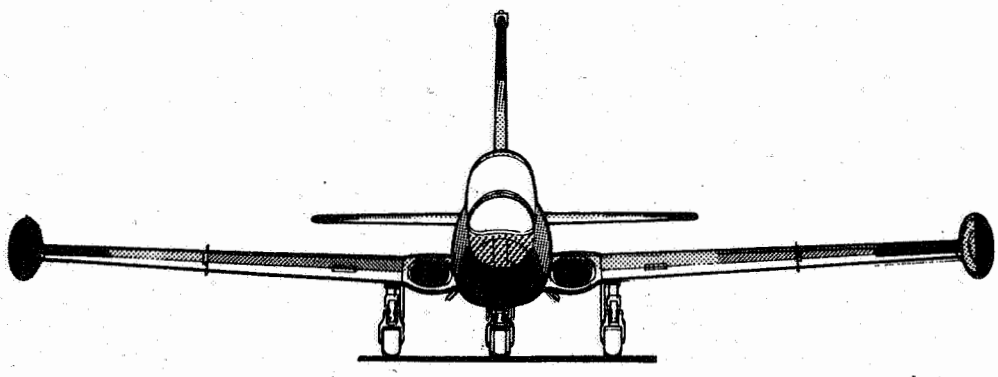


Figure 1-0.

PART ONE

INTRODUCTION

PART ONE - CHAPTER I

INTRODUCTION, GENERAL INSTRUCTIONS AND RESTRICTIONS

TABLE OF CONTENTS

Title	Page
For Pilot's Attention	1-1
Information on Aircraft	1-2
Preparation of Flight	1-3
General Instructions	1-4

1. FOR PILOT'S ATTENTION

a. General

The information and recommendations in this manual are intended as a starting-point and a reference for the preparation of the lessons and the planning of the individual flight missions.
The majority of the techniques and flight skills can be acquired only through a long contact-talk with the instructor.
After gaining sufficient confidence as a pilot, the student will develop and expand his ability to exercise sound judgement and will refine his piloting technique.
The procedures in this manual contain subsidiary information for use of the MB-339A aircraft in the training role. However, because of the multitude of different conditions that may be encountered during flight, the procedures treated herein can result to be inadequate to face particular situations.
Much study, determination and effort will be required to gain the level of knowledge and proficiency necessary to achieve the basic skills that an Air Force pilot is requested to possess.
A thorough knowledge of the Flight Manual, Weapon Delivery Manual, Basic Weight Check List and Loading Data as well as of the applicable checklists will mainly be required.
The operational restrictions, the prescribed and prohibited procedures, the correct maneuvers in the right sequence under standard and emergency conditions, are established only by these official publications with disciplinary and legal effects.
Navigation and instrument flight training requires knowledge of this manual as well as of the "Instrument Flying and Navigation Manual" PI AD-03-39A. Moreover, the advanced phase of tactical training and the use of the aircraft as a light fighter-bomber will refer to the techniques, procedures and recommendations contained in the "Tactical Manual" PI AD-02-39A.
To provide sound bases for the preparation and performance of all the basic and advanced flight missions envisaged by the programmes, this manual contains the detailed and "sensory" description of the single maneuvers performed in flight, to reproduce the visual, instrument and physiological situations in the memory of the student pilot thus allowing him to mentally prepare himself for the sensorial reactions he will encounter in flight.
In this way, most of the flight events will be exactly envisaged and planned, and the student pilot will have the possibility of concentrating

with greater profit on the application of the procedures and the performance of the maneuvers.

b. Recommendations to Student Pilot

The instructions and recommendations contained in this manual will always be checked for compatibility with the Flight Manual PI 1T-MB339A-1 (which will be referred to in the following pages as FM).
The precaution of accomplishing this type of cross-check must become a habit with the pilot.
The pilot will also consult the Standing Operational Procedures (SOP) in force at the base, in the areas of operation, gunnery ranges, etc., and the procedures covering air traffic.
Besides, the pilot will memorize (but not rely on memory alone) the procedures contained in the Pilot's Checklist PI 1T-MB339A-1CL-1.
Knowledge of the FM will be verified by written examination (questionnaire) upon completion of the Ground Training School.
The student pilot is recommended:

(1) to cooperate with the instructor also in the phases that precede and follow the flight;

(2) to have the utmost trust and confidence in the instructor. Have no fear to ask questions: no question is trivial.

(3) To familiarize with the aircraft cabin. Get used to know the cockpit with closed eyes.

(4) To mind the documentation required during the flight (maps, checklist, flightplan etc.).

(5) To mind his flight equipment.

2. INFORMATION ON AIRCRAFT

MB-339A aircraft means:

- M: ...MACCHI... designed and manufactured by AERMACCHI SpA-Varese
- B: ..Bazzocchi... responsible for aircraft project
- 339: aircraft type
- A: ..A series..

The MB-339A (fig. 1-1 and 1-2) is a single-engined, jet aircraft destined to initial basic and advanced training with capacity for the secondary role of light fighter-bomber.
The tandem two-seat configuration with the instructor's seat 32 cm higher than the student's seat allows both pilots to have the maximum visibility both forward and sideways. The aircraft is powered by a straight turbojet (no by-pass), single-spool engine with an eight-stage axial compressor, an annular combustion chamber and a two-stage turbine.
The engine is of the Viper 632-43 type, (fig. 1-3) designed by Rolls-Royce. The engine has a testbed nominal thrust of 4000 lb and a S.L.S. thrust of approx. 3650 lb, because of the thrust losses due to the air intakes, the ducts and the jet pipe.
The aircraft empty mass (fully empty, with engine oil and hydraulic fluid) is 3140 kg and the maximum take-off and landing mass is 5900 kg.
The aircraft take-off mass for a training flight (crew of two plus full internal fuel, no external store) is 4400 kg.
Six underwing strong points are provided for the installation, through

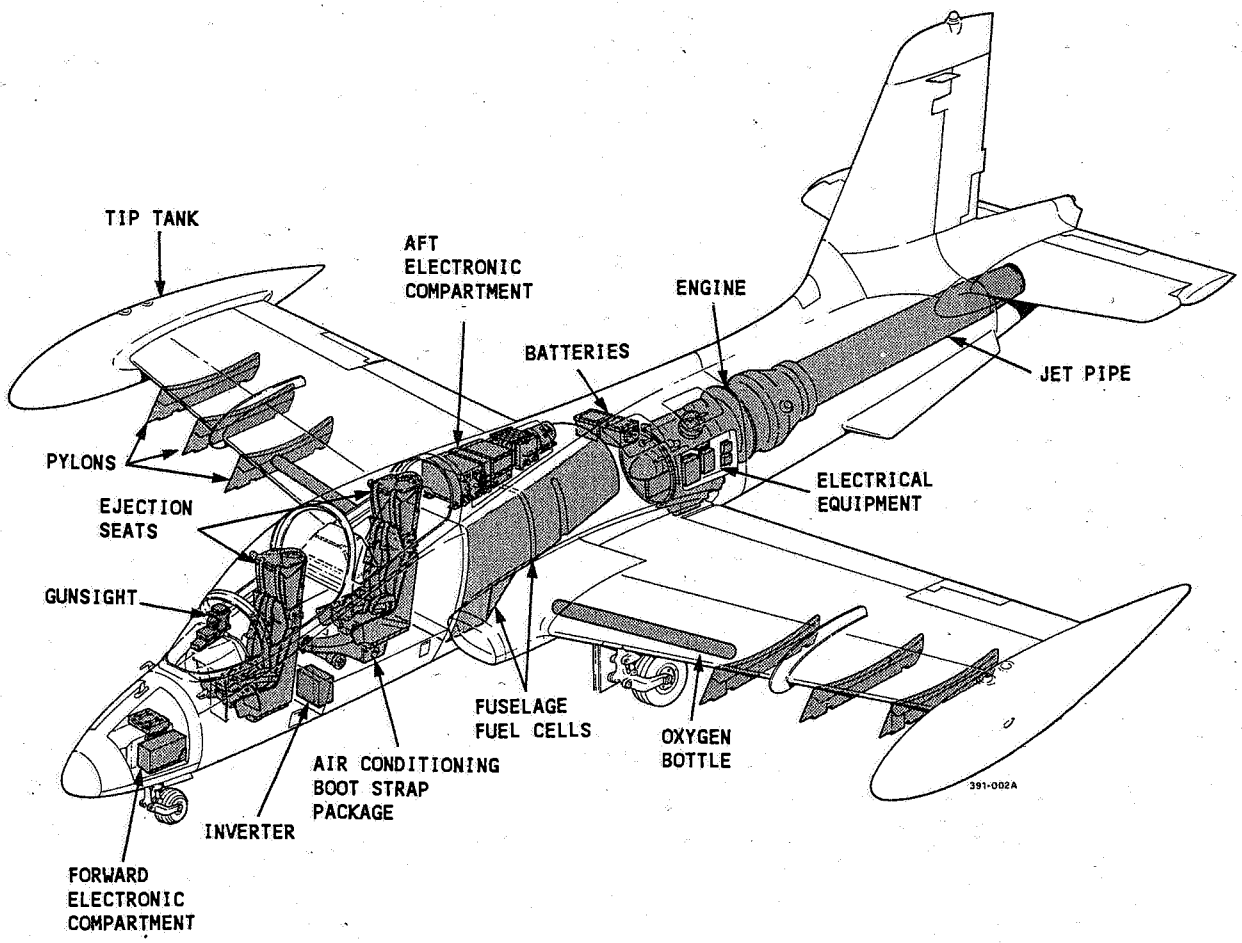


Figure 1-1. General Arrangement

pylons, of external (droppable) stores such as : bombs, tanks, rocket launchers, dispensers, etc.
Non-droppable stores, such as gun pods, machine gun pods and photo--reconnaissance pods can be directly installed at inboard points 3 and 4.
All data on the aircraft is contained in the FM.
Data useful for mission planning is contained in the "Instrument Flying and Navigation Manual" PI AD-03-39A.

3. PREPARATION OF FLIGHT

To get the utmost profit from a flight lesson, it is necessary :

a. To study and exactly understand the lesson plan in detail by referring also to the FM, this manual and all material available to further familiarize with the techniques and procedures.

b. To have the flying equipment in good order.

c. To reach the aircraft with:

-Checklist

-Navigation charts

-Flightplan form and other documents (refer to Chapter III, para 2.d)

d. To check and accept the aircraft as instructed in Chapter III, para 2.f.

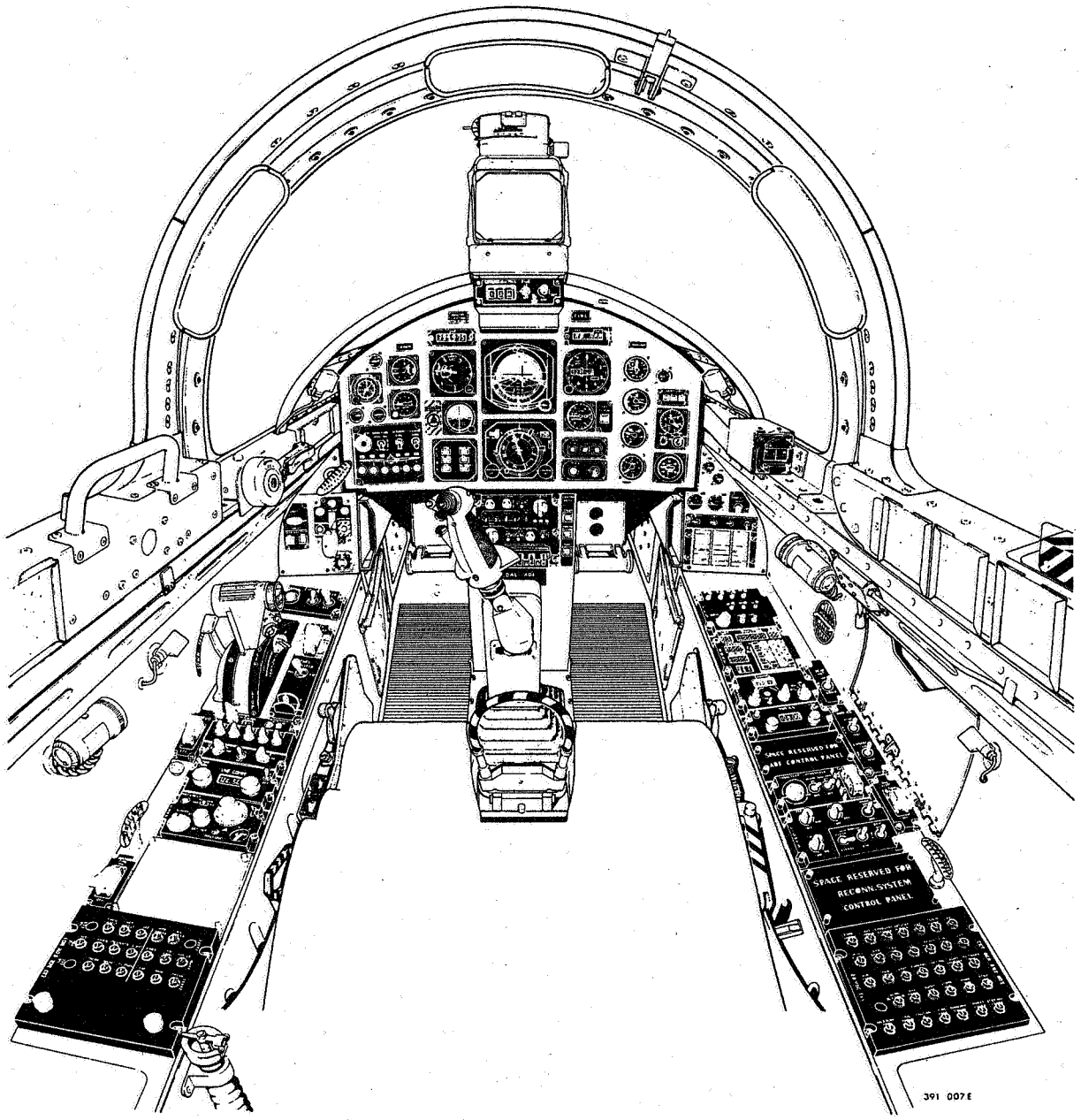


Figure 1-2. Front Crew Station

4. GENERAL INSTRUCTIONS

a. Dual Flights

An important requirement during all dual flights is a clear and positive understanding of who has control of the aircraft.
The interphone procedure to transfer the aircraft control is as follows:

INSTRUCTOR: "YOU HAVE THE AIRCRAFT"
STUDENT: "I HAVE THE AIRCRAFT"

The instructor assuming control will say:

INSTRUCTOR: "I HAVE THE AIRCRAFT"
STUDENT: "YOU HAVE THE AIRCRAFT"

Controls are relinquished only when command and answer have been given. Who has control of the aircraft will then shake the stick noticeably.

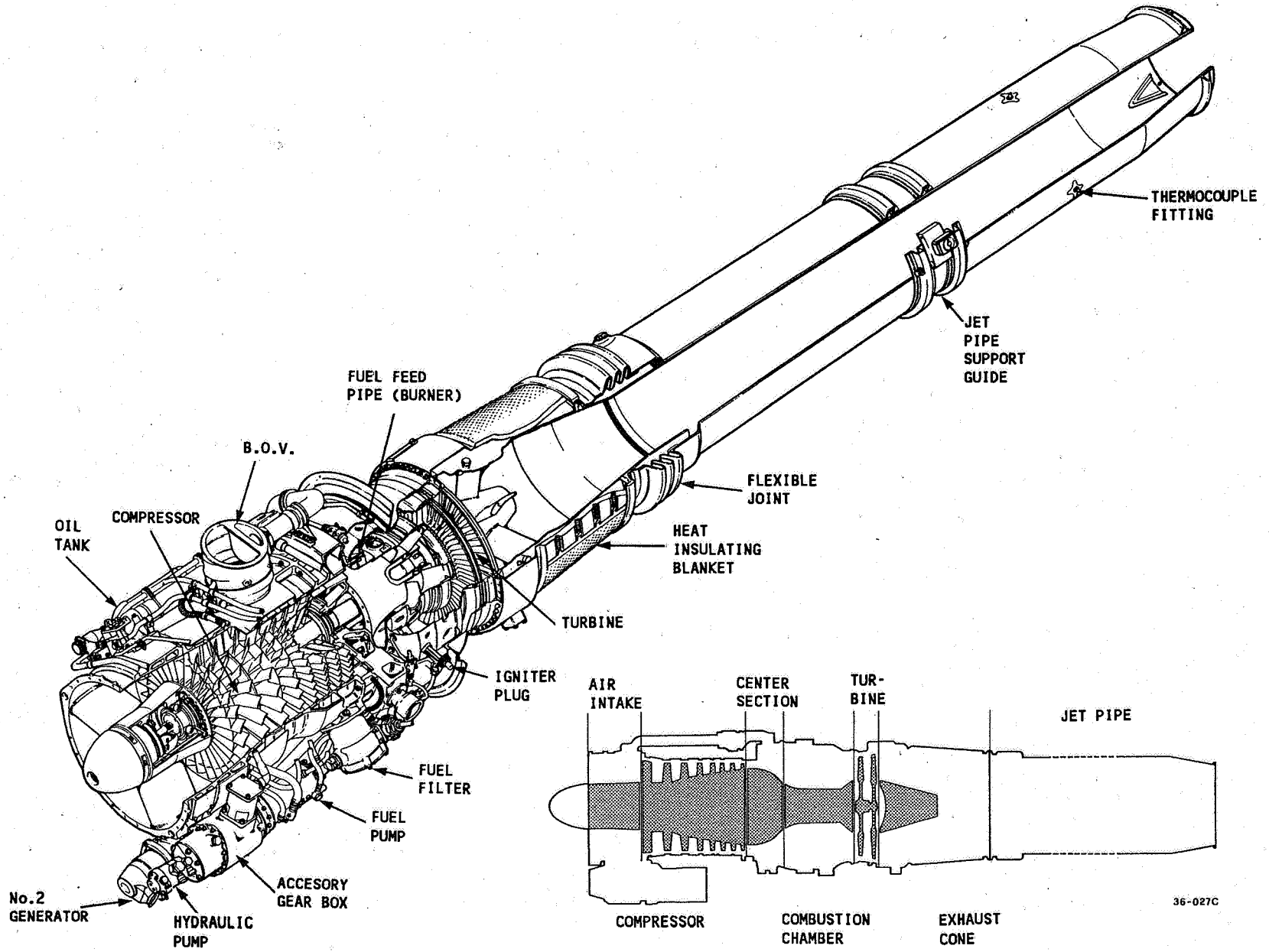


Figure 1-3. Viper MK 632-43 Engine

b. Visual Flights, even with IFR Plan

The traffic must always be followed with attention. Any other aircraft in flight must be detected and memorized. The bearing is always referred to your aircraft heading and altitude according to the "clock" method, viz.: "C-130 aircraft at ten o'clock, higher", means relative bearing approx. 300 degrees and altitude above that of your aircraft.
On dual team flights, use the challenge/response system to check the bearing.
If the bearing remains constant in the time, your are flying a collision course (or a crossing course, if altitudes are different).
If the bearing moves TO NOSE, the other aircraft will pass ahead.
If the bearing moves TO TAIL, the other aircraft will pass astern.
During flight, always assume that the other aircraft has not seen you, and observe the directives and rules set forth in Chapters VII and X herein to avoid collisions.
Before performing any maneuver, whether aerobatic or not, make sure that the area of maneuver is clear.

c. Solo Flights

It is imperative that the prescriptions contained in Section II of the FM be followed.
The instrument hood, if installed, must be in the open and locked position.
The totally exceptional stowage of items in the rear cockpit is permitted only to instructors. Items are to be securely fastened to the rear seat and aerobatic maneuvers are prohibited.
Solo students must request landing priority when the "FUEL LOW" caution light is on. Obviously landing must be FULL-STOP.

d. Aerobatics

An anti-g suit must be worn when aerobatics or other high load factor (more than 3 g) maneuvers are expected.
Inverted spin is permitted only to qualified instructors and at altitudes above 15000 ft AGL.
An intentional spin with asymmetric load or unbalanced fuel in tip tanks is prohibited (see FM, Section V).
Student pilots are not allowed to perform an intentional spin with fuel (even symmetrical) in the tip tanks.
Unusual attitudes connected to extremely low speed are prohibited in presence of underwing stores or asymmetric stores and are not permitted to student pilots when fuel is present in the tip tanks.

e. Weather Restrictions

(1) Unusual attitude practice in IMC is prohibited.

(2) Intentional flight in IMC and/or in areas of heavy precipitation or of continuous moderate or heavy ice formation is prohibited.

(3) Intentional flight in IMC from or to airfields of forecast icing conditions at low altitude (less than 5000 ft AGL) is prohibited.

(4) All position ligths and anti-collision lights must be turned on in IMC flights.

(5) In solo flights, the student pilot can be authorized time by time to fly portions of flight in IMC provided the weather conditions on the landing Base are:

- visibility is 3 nmi or more
- cloud base is at least at 5000 ft AGL
- cloud cover is no more than 1000 ft thick

f. Other Restrictions

(1) Carrying any type of cameras in training flights is prohibited.

(2) Landing gear safety struts, pins, covers and blanks for dislocated parking can be carried in flight with the adequate fastening precautions only when a dislocated flight is planned.

(3) For dislocated flights, the aircraft should be fitted with the baggage underwing pod. In this case, the parking equipment should be stowed in the baggage underwing pod.

(4) Placing the helmet, harness, lap strap, leg garters or other flight equipment on the internal dome of the open canopy or between the instrument panel and the windshield, is absolutely prohibited.
The acrylic material of the transparencies is soft, can be easily scratched and scored and is very costly.
Always handle the aircraft with care as your own car, as far as the integrity of transparency, painting, etc. is concerned.
Following these directives and making sure that they are observed also by the specialists and all personnel handling the aircraft, must become a habit for a good pilot.

(5) The student pilot will not fly an aircraft with a malfunction not preventing flight (such as a faulty Flight Director) unless cleared by his instructor.

(6) The following precautions must be taken to reduce the risk of foreign object damage during ground operations:

(a) Avoid taxiing too close to the preceeding aircraft.

(b) If possible, always taxi with the engine at idle.

(c) Reduce power to the minimum when another aircraft has to pass behind your aircraft. Ask the pilot of the preceding aircraft to reduce power to the minimum.

(d) Do not get close the air intakes of an aircraft with the engine running.

(e) Pay the utmost attention not to handle objects, maps, gloves, caps, etc. in proximity of the air intakes of an aircraft with engine running.

(f) Start the engine with the canopy closed or partially closed.

PART ONE - CHAPTER II

FLIGHT CHARACTERISTICS

TABLE OF CONTENTS

Title	Page
Foreword	2-1
Aircraft Motion in Space	2-1
Flight Controls	2-2
Forces and Moments	2-5
Controls to be Used on the Ground Only	2-8

1. FOREWORD

Section VI "Flight Characteristics" of the FM illustrates the aircraft general flight characteristics, as well as the aircraft behaviour, and the maneuvers for recovery from:

- stall
- erect spin
- inverted spin
- unusual attitudes

This section also illustrates the flying qualities, the effectiveness of the controls and the correct procedures to fly in the different conditions of load, speed, etc.
The information and instructions provided hereafter are merely an extension and a comment of what is set forth in the FM.

2. AIRCRAFT MOTION IN SPACE

Let us run three orthogonal axes through the aircraft center of gravity (fig. 2-1), namely:

- the aircraft longitudinal axis, or X axis
- the aircraft lateral axis, or Y axis
- the aircraft (improperly termed) vertical axis, or Z axis

The three axes are integral with the aircraft, and axes X and Y will therefore lie in the horizontal plane and axis Z in the vertical plane occasionally only.
The rotations of the aircraft about its characteristic axes are called:

Yaw about the Z axis

Roll about the X axis

Pitch about the Y axis, i.e. a motion in the aircraft symmetry plane.

The above movements are due to forces that are not applied to the aircraft CG.

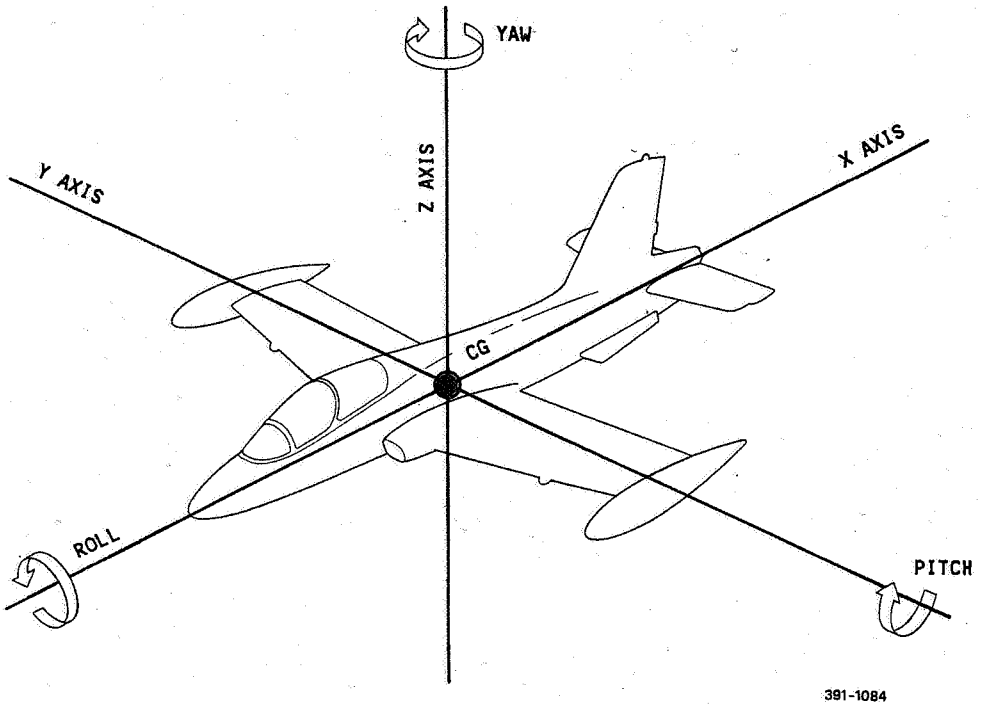


Figure 2-1. Moments Applied to Aircraft

3. FLIGHT CONTROLS

The aircraft controls are the devices which serve to change the mechanical and inertia aerodynamic moments and forces that are applied to the aircraft. See FM, Section I.

a. Main Flight Controls

(1) Rudder: it is controlled by the rudder pedals. Applying right foot pressure as shown in figure 2-2, deflects the rudder to the right and creates a CROSS-LIFT force of the vertical empennage to the left. The aircraft tail thus moves to the left and the nose yaws to the right. When applying left foot pressure, the motion takes place in the opposite direction.

(2) Ailerons: the ailerons are controlled by the lateral deflection of the control stick. The aileron on the wing toward which the stick is moved goes up, while the aileron on the other wing goes down.
Through the action of suitable linkages, the aileron that goes up has a greater range of travel than the aileron that goes down (differential deflection), and it places a greater drag on the forward movement of the wing that lowers. Moving the stick to the right, as shown in figure 2-3, therefore creates an increased lift on the left wing which goes up, and a decreased lift on the right wing which goes down, concurrently creating a greater drag on the right and taking the aircraft into a correct turn to the right (ball centered) with no action on the rudder.
In the MB-339A the ailerons are servo-controlled and the control includes an artificial feel device. In case of servo-control failure automatic reversion to manual will occur. At a speed higher than 350 KIAS, stick forces in "manual" mode become very high, in spite of the aerodynamic balancing by tabs.

(3) Elevator: the elevator is controlled by the longitudinal deflection of the control stick. It is aerodynamically balanced, but not servo-controlled.
Stick deflection must be smooth and even not to impose high load factors.

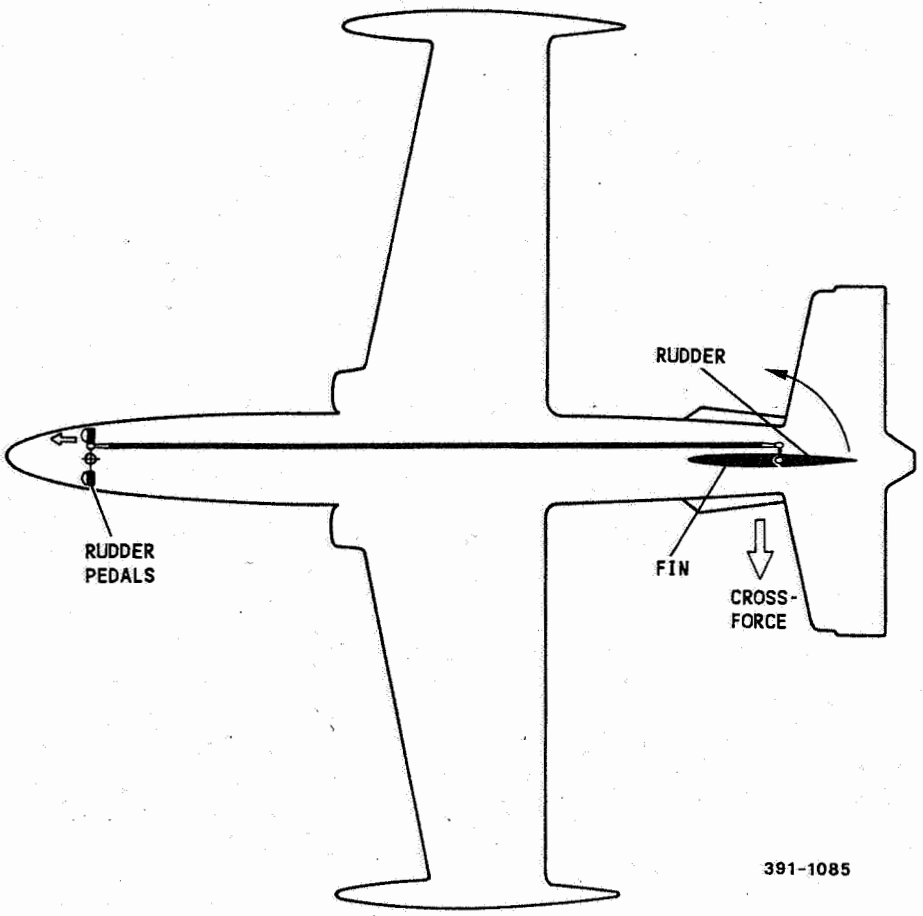


Figure 2-2. Rudder Control

The elevator control operates as shown in figure 2-4.
The stabilizer position - the stabilizer is fixed in this aircraft - is such as to generate, in combination with the elevator, a negative lift, thence a nose-up moment which balances out the nose-down moment due to the aft CG location of the lift force.
This makes the aircraft self-stabilized in pitch.
When moved up, the elevator creates a negative lift, when moved down it creates a positive lift, with consequent nose-up or nose-down moment.

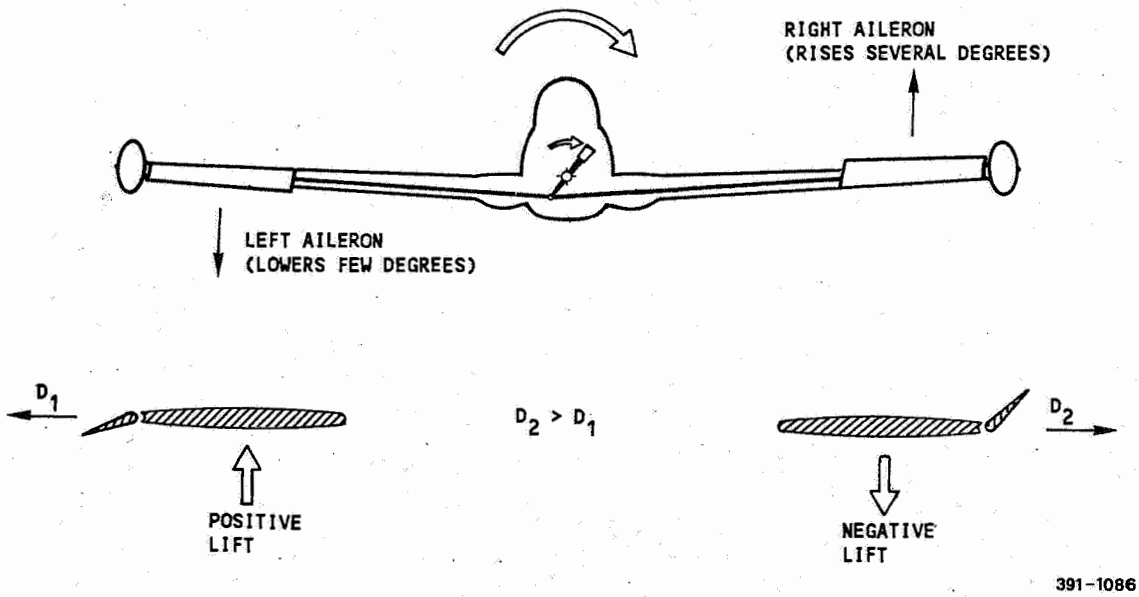


Figure 2-3. Aileron Control

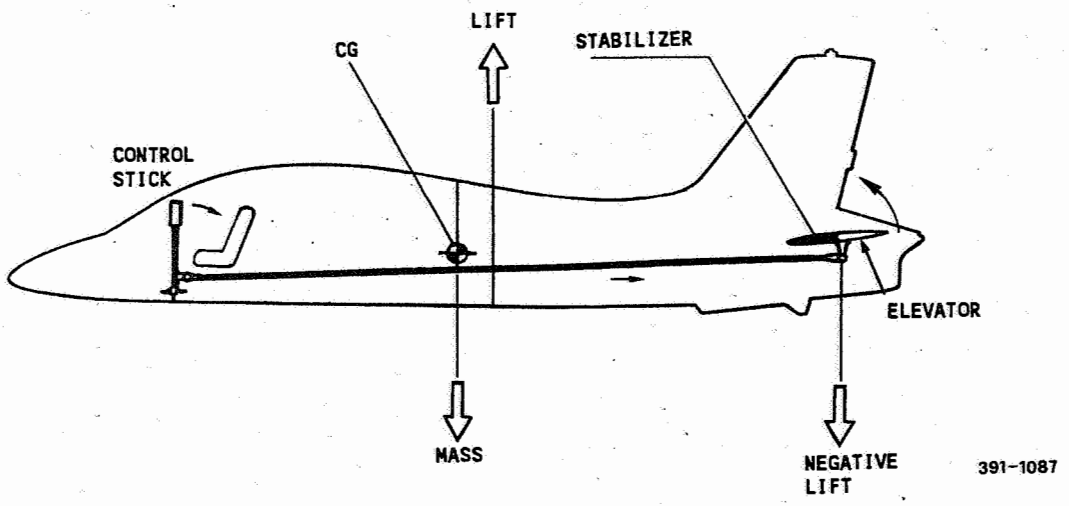


Figure 2-4. Elevator Control

b. Auxiliary controls

(1) Speedbrake: the speedbrake is controlled by a switch (with center-off position), located on the engine throttle lever.
Actuating the switch aft (to... slow down) causes the extension of the speedbrake, which is moved down by a hydraulic jack.
The result is a remarkable increase in the aircraft drag accompanied by a slight and well controllable nose-up moment.
Releasing the switch, which springs back to the center-off position, stops the speedbrake in the attained position.
To retract the speedbrake, the switch must be actuated forward (... to accelerate). In this case, too, when the speedbrake switch is released, the speedbrake stops in the attained position.

(2) Flap: the MB-339A aircraft is equipped with Fowler lift augmenting devices (flaps) extending along the trailing edge of the wing between the fuselage and the aileron.

The flaps extend down and aft, thus providing:

- an increase of wing area

- an increase of the velocity of the air flowing through the slot between wing and flap

- an increase in lift (increase of profile curvature)

- a rather small increase in drag when extended to the T/O position, and a large increase in drag when in the DOWN position

The flaps are controlled by a lever located near and to the outside of the engine throttle lever (see FM, Section I).

(3) Trimming devices (see FM, Section I).

(a) Aileron trimming: in case of asymmetric loading, the aircraft has a tendency to lower the most loaded wing.
To avoid counteracting this tendency by continuous opposite action on the stick, the aileron control system in the MB-339A aircraft is provided with a device which displaces the neutral point of the spring that returns the stick to the center-off position.
The aileron trim system is actuated by moving the center-off position switch located on the top of the control stick grip, to right or to left.
Lateral trimming is obtained in the same way either when the ailerons are servo controlled or when the servocontrol hydraulic actuators are deactivated, as in the case of insufficient hydraulic pressure.

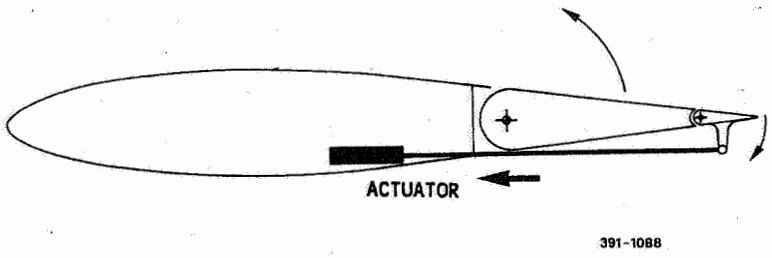


Figure 2-5. L.H. Elevator Trim Tab

In the latter case, the manual maneuver can always be aided by the trim and is made less heavy by the balance tabs mounted on the trailing edge of the two ailerons (see FM, Section I).

(b) Elevator trim: forward and aft actuation of the switch located on the top of the control stick grip controls (through an electrical actuator) the trim tab mounted on the left elevator.
When a nose-down tendency of the aircraft is to be corrected, the switch on the stick is moved for nose-up and, through action causes the electrical actuator in the left stabilizer, it moves the trim tab down. The resulting aerodynamic force will move the elevator up thus causing a nose-up moment.
The left tab functions also as a balance tab since any movement of the elevator causes the tab to move in the opposite direction.
The function of the tab on the right elevator is merely to aid in reducing elevator stick forces (this is a non-adjustable tab which moves in a direction opposite to the elevator deflection).

(c) Rudder trim: the trimming of the directional control to compensate for aerodynamically asymmetric external loads is obtained by a trim tab installed in the rudder trailing edge and actuated by an electrical device similar to that used for the elevator.
The "RUDDER TRIM" switch is located on the left console near the engine throttle lever (see FM, Section I).

(d) Thrust control: engine throttle lever: the increase or decrease of the engine thrust is controlled by the engine throttle lever, operated by the pilot's left hand. Moving the throttle forward increases the engine RPM, retarding it aft decreases the RPM down to IDLE.
To shut the engine down from the idling position, will be necessary to release the detent by lifting the fingerlift with the forefinger and middle finger of the left hand and then retard the throttle to the full aft travel position (for throttle operation see FM, Section I).

(e) Actions and interactions of controls: see following paragraph 4c in this chapter.

4. FORCES AND MOMENTS

a. Forces Applied to the Aircraft (fig. 2-6 and 2-7)

They are essentially four: lift (L), mass force (nxW), traction (or thrust) (T), drag (D).
The lift (L) is the resultant of the lifting forces and is normal to the direction of velocity (direction of slip streams upstream of the aircraft)
The drag (D) is the resultant of the resisting forces and is parallel to the velocity vector.
The X and Z axes of the aircraft are orthogonal to each other and coincident respectively with the V and L axes in one flight condition only.
The direction of the mass force (or nxW) is always along the apparent

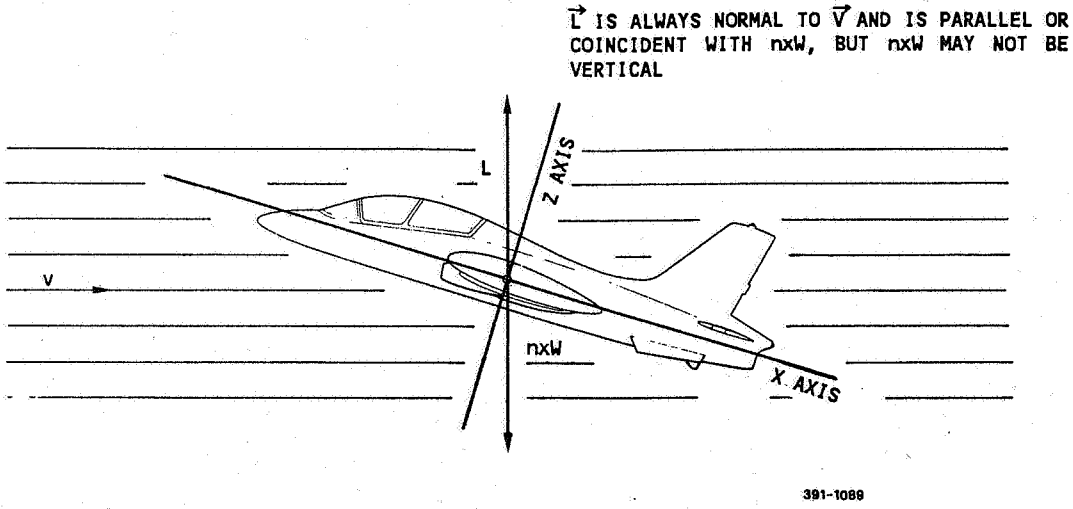


Figure 2-6. Lift and Inertial Forces

vertical and its intensity is a function of the mass by the normal acceleration (normal to V) in straight-and-level flight W = aircraft mass, also in climb or dive, but L = W constant.

b. How to Control Forces and Moments

The pilot carries out the steering actions by acting on the controls so as to change the forces and moments applied to the aircraft CG as required.
With the engine throttle, he can change the thrust.
By moving the control stick laterally, he creates roll moments.
By moving the control stick longitudinally, he creates pitch moments.
With the rudder pedals, he creates yaw moments.
Yaw and roll moments have an interaction. Some design features minimize the roll-induced yaw.
Drag can be increased, when thrust reduction is not sufficient to slow the aircraft down, by extending the speedbrake.

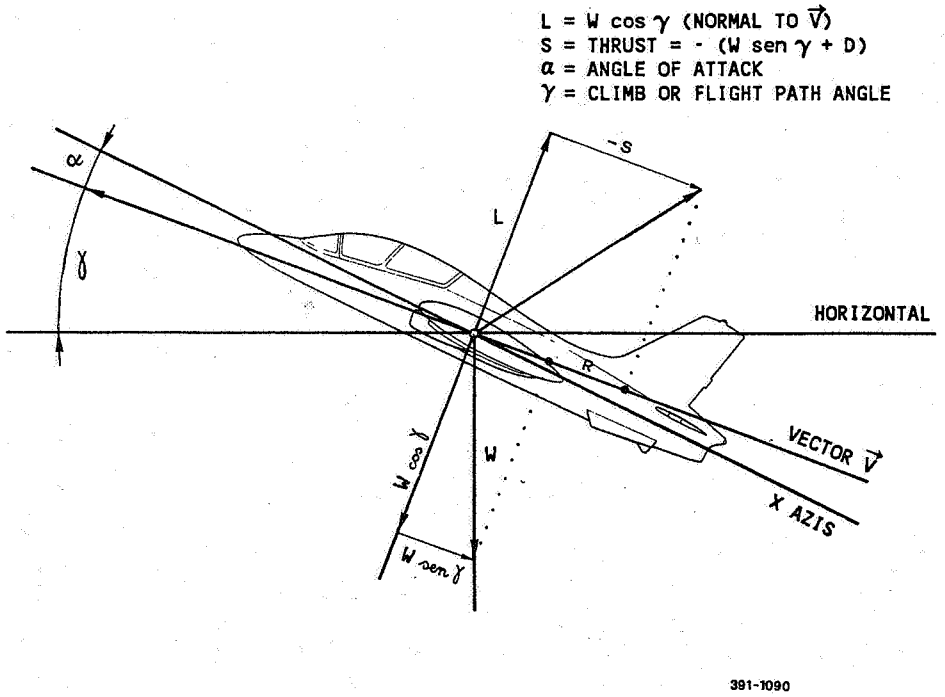


Figure 2-7. Forces Applied to Aircraft in Rectilinear and Steady Climb

The wing lift can be increased by lowering the flaps to the T.O. position; this also involves a small increase in drag.
If conversely the flaps are set to DOWN (fully extended), drag will increase remarkably permitting greater glide angles to be flown without increase in speed (landing).
The aircraft will be in an equilibrium condition about the three axes with stick free only in one condition of mass and speed.
For all other conditions the aircraft will be subject to longitudinal (climb or dive) moments, lateral (left roll and right roll) moments or, due to aerodynamic asymmetries, to left or right yaw moments.
To bring the aircraft back to a condition of equilibrium in order to obtain moments equal to zero in all flight conditions, i.e. a stick free stability, the use of balancing or trim devices is necessary.

c. Effects Induced by Control Maneuvers

(1) Rudder: a large rudder deflection causes a large yaw and thus a decrease in the speed of the wing that is internal and an increase in the speed of the wing that is external to the yaw. The result of this is an induced roll in the direction of yaw.

(2) Aileron: since the aileron deflection is not symmetrical but differential (the aileron that goes down deflects less than the up-going aileron), the lateral movement of the stick causes not only a roll but also a true turn on the side of the wing which lowers and produces a greater drag.
The differential action of the ailerons, in addition to preventing adverse yaw, is capable of generating a correct turn (ball centered) with no operation of the rudder throughout the aircraft normal maneuver envelope.

(3) Elevator: longitudinal movements of the stick require a push-pull force proportional to the load factor (g) which is applied to the aircraft (averagedly 3 to 4 kg per G) at the normal maneuver speed.
At lower speeds the control stick is lighter and more pleasant (e.g. in the landing phase).

(4) Speedbrake: the speedbrake is installed on the fuselage bottom and, when the landing gear is retracted, it can take any intermediate position between full up and full down. Conversely, when the landing gear is down, speedbrake extension is limited for ground clearance on touch-down.
The speedbrake control is located on the engine throttle (see FM, Section I and paragraph 2 of this Chapter).
When extended, the speedbrake produces a remarkable increase in drag accompanied by a beneficial, non-violent, nose-up tendency which is a function of speed. It can therefore be operated also at very low altitude and very high speed.
The speedbrake is scarcely effective at very low speeds.

(5) Flaps: the flaps can be selected to 3 positions by a lever located on the outside of the engine throttle:

- UP position - Flaps retracted

- T/O position - Take-off: flaps lowered to intermediate position for take-off

- DN position - Down: flaps fully down for landing

Lowering the flaps causes a nose-up moment which is to be counteracted to hold the flightpath.
The subsequent decrease of speed reduces or eliminates the initial nose-up moment.

(6) Power: engine thrust is controlled by the throttle. The minimum thrust (engine at IDLE) corresponds to the aft position of the throttle, the maximum thrust to the full forward position of the throttle. The throttle movement is designed to give thrust increments proportional to the throttle travel.
A throttle in mid position means: half the maximum thrust (and not half the maximum rpm).
The number of rpm in fact is neither proportional to the thrust nor to the throttle travel: with 86% rpm, thrust is approx half the maximum and the throttle is at half travel between IDLE and maximum. With large approximation it can be said that thrust is proportional to the third power of RPM.
Thrust is conversely proportional to the fuel flow. At any altitude, the flowmeter gives good indications to this effect. In first approximation, thrust in kg is nearly equal to the value read on the flowmeter (kg/min) multiplied by 60 (or multiplied by 135 if thrust is in pounds).
Remember that the power available is equal to the thrust multiplied by the airspeed (TAS).
The increase in thrust (throttle advanced) causes a slight nose-up moment, and the consequent increase in speed still increases the aircraft tendency to climb.
Forward pressure on the stick and the subsequent action on the elevator TRIM will bring the aircraft back to a balanced condition. The opposite occurs when the throttle is retarded.
On the ground, during the take-off run, the rolling friction of the main wheels rotate moves the application point of the aircraft total drag to a very low position. The (maximum) thrust along the jet axis threfore produces a noticeable initial nose-down moment which becomes weaker as velocity increases, but does not become zero until the aircraft is airborne.

5. CONTROLS TO BE USED ON THE GROUND ONLY

a. Steering

The nosewheel steering is hydraulically actuated through the movement of the rudder pedals, by an electrical signal which, at pilot's will, energizes two opposed hydraulic actuators only when the nosewheel is weighing on the ground (see FM, Section I).

b. Wheel Brakes

Under normal conditions, the brakes are operated by toe pressure on the rudder pedals regardless of the position of the rudder pedals. Pressing the right toe pedal commands braking of the right main wheel. Pressure on the left toe pedal will be required to brake the left main wheel.
Braking is proportional to the amount of pressure applied to the pedal.
Under emergency conditions the brakes are operated through a handle located on the left side panel of the instrument panel. In this case, the braking action occurs on both wheels concurrently, although the braking action can be modulated by pulling the handle more or less out.
The emergency brake is also used as a parking brake by pulling and rotating the brake handle in the front cockpit (see FM, Section I).

c. Locking of Controls on the Ground

When the aircraft is parked, it is advisable that the flight controls be always locked (except for the ailerons which are locked by their servo-control).
To lock the controls, refer to Section I of the FM.

PART ONE - CHAPTER III

PRE-FLIGHT AND POST-FLIGHT PROCEDURES

TABLE OF CONTENTS

Title	Page
General	3-1
Pre-flight Operations	3-2
Debriefings	3-4

1. GENERAL

The operations to be carried out by the pilot before and after the flight are many and not less important than the flight itself.
They consist of the following:

a. Pre-flight Operations

(1) Check of personal equipment and donning

(2) Mission briefing

(3) Detailed planning of the different flight phases in conformance to the instructions received during the briefing

(4) Selection and preparation of the documentation to be taken on board

(5) Planning of the times required for mission performance and coordination with the Air Base general planning

(6) Request for the necessary traffic and operation clearances

(7) Pilot's pre-flight check and aircraft acceptance

(8) Cabin checks and engine starting

b. Pre-flight Ground Maneuvers - See Chapter IV

(1) Taxiing in accordance with the briefing instructions confirmed or modified by TWR

(2) Checks and lineup

(3) Checks before take-off

c. Post-flight Ground Maneuvers - See Chapter IV

(1) Checks after landing

(2) Taxi run to parking area

(3) Engine shut-down and cabin post-flight checks

(4) Return of aircraft to the crew chief

d. Debriefing

(1) Operational mission debriefing

(2) Training debriefing (by the instructor) on the behaviour in flight and maneuvers

(3) Technical debriefing on aircraft failures/malfunctions.
Omission of none of the above operations is allowed

2. PRE-FLIGHT OPERATIONS

a. Check of Personal Equipment and Donning

(1) Helmet: clean and in good condition; visor: clean and unscratched; earphones in place; wires: undamaged; mask connectors and chin straps: undamaged and serviceable.

(2) Mask, valves, microphone, helmet connections: in good conditions; cables: undamaged; corrugated hose: without cracks; interphone plug and corrugated oxygen hose connector: in perfect conditions.

(3) Underwear and flying clothing: clean and dry

(4) Anti-g suit: thoroughly fit to the pilot's size; air bladders: undamaged; knife: tight in its sheath on the calf; connection to anti-g valve: undamaged.

(5) Life jacket: check that lifejacket and CO^2 cylinders are in good condition; check ring or buckle for lanyard connection to the survival pack; check radio and batteries, antennas and cables for integrity; check the survival kit (uranine, whistle, anti-shark powder, Minilux distress signals, etc.)

(6) Boots: clean, (soles too), and in good condition

(7) Gloves: in good condition

b. Mission Briefing

The collective morning briefing on Base procedures, traffic, traffic restrictions, radio-assistance and infrastracture status, meteo conditions, etc. must be followed by the instructor's briefing on the specific mission.
It is important that in the morning briefing, a few minutes be dedicated every morning to comment on the FM emergency procedures or on the standing operating procedures (SOP) of the Base traffic.
In mission briefing, the instructor should mainly refer to this manual and the FM.

c. Detailed Planning of Flight Phases

By referring to the "Instruction Program", the instructor and the student together will prepare the sequence in chronologic order of the maneuvers and checks that are to be carried out during the mission.

d. Preparation/Selection of Documentation to Be Taken on Board

Besides the always needed checklist and the local area map in 1:500.000 scale, under the instructor's guidance, the student will prepare the following:

- Table of the possible diversions to alternate airfields (course, distance, time-to-fly, fuel consumption, radio-aids, etc.)
- Table and/or map to reach the area of activity and come back
- Navigation maps and flightplan for navigation or cross-country flights
- List of navigation aids

e. Planning of Flight Times

Ask the Air Traffic Control to confirm the following: times for take-off and landing, area of activity and times of flight IN and OUT the area. From this plan back:

- Time for starting the engine
- Time for exterior/interior checks

Ask the Serial Number of the assigned aircraft in time and instruct the crew chief on the following:

- Time of acceptance of pre-flown aircraft
- Required fuel
- Required operational equipment (underwing tanks, blind flying hood, gunsight, training armament, etc.)

f. Pilot's Pre-flight and Aircraft Acceptance

(1) Review the aircraft historical records in aircraft logbook

(2) Carry out the aircraft exterior checks specified in the checklist

(3) Accept the aircraft by signing the aircraft logbook

g. Cabin Checks and Engine Starting

Before entering the cabin don the life jacket, checking its zip fastener and ensuring that no objects that are expected to be of use in flight are forgotten under the life jacket in the breast pockets of the flying clothing.
Don garters and gloves.
If there is the possibility of being helped by the crew chief, the helmet and lap strap should be rested on the left wing (and not on the canopy or on the antiglare shield), and donned after the interior checks.
Carry out the prescribed "BEFORE ENTERING COCKPIT" checks. Enter the cockpit and if possible get some help to route the parachute harness and the lanyards of the survival pack.
This is a rather complex operation which must be carried out with care and deliberation.
Remember that during aerobatics it is important for you to "make up" a whole with the seat, and the belts should therefore be tight but not so much as to cause disturbance.
Follow the "IN CABIN" procedure: don the helmet, the lap strap, then still with the aid of the checklist, carry out the interior checks (in a loud voice if the mission is a dual sortie) and the pre-starting checks.
Before starting the engine carry out the following:

- Check that the engine starting time is as planned
- If necessary, obtain the TWR clearance for starting the engine
- Obtain the instructor's go-ahead: signal your intention of starting the engine to the crew chief by raising the right forearm vertically, forefinger raised and the other fingers fisted, then rotate repeteadly the forefinger.

The crew chief will reply affirmatively by the same gesture or negatively by showing the hand palm (hold signal).
Carry out engine starting as per the checklist.
The checks before taxiing must be carried out as per the checklist, as well.

The speedbrake and flap deflections must be carried out on signal by the crew chief (see "Parking Crew Signals" in Chap. IV).
Before taxiing is started, make sure that the area in front and on the side of the aircraft is clear.
The crew chief will normally stand in front and on the left side of the aircraft with his both hands fisted at face level (brakes applied); then, when the area is well clear, he will make sign to start taxiing by moving his hands back and forth, palms towards his face.

3. DEBRIEFINGS

After returning the aircraft to the crew chief and signing the logbook, the instructor and the student or the student in solo will debrief as required.

a. Operation Debriefing

- It is required after ferry flights, aerotactical navigation or firing missions, etc.

- It is carried out by the pilot or the formation leader in front of the Air Traffic Control representative.

- It concerns the mission operational aspects

b. Flying Safety Debriefing

When required the squadron flying safety officer will ask for detailed comments on events which are related to or might be related to flying safety (danger conditions, critical failures in flight, malfunctions of the flight assistance system, etc.)

c. Technical Debriefing

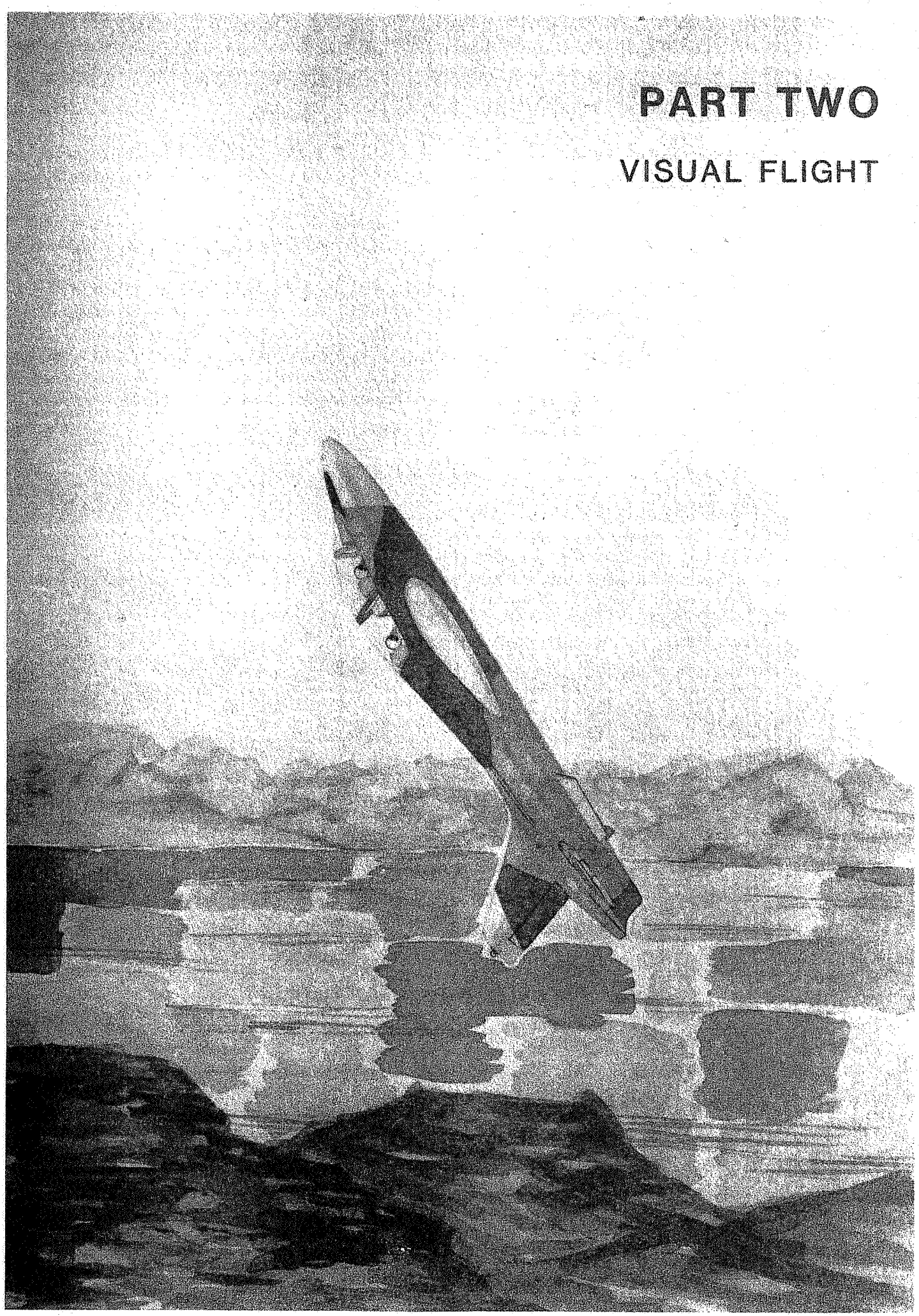
When required, the squadron technical officer will ask for a detailed report of the malfunctions or of any operation in flight of the aircraft and its equipment, when the simple records in the aircraft logbook are not sufficient to provide data useful for defect investigation and troubleshooting.
It should be the pilot's initiative to cooperate with the Technical Activity by providing exhaustive information on the subject.

d. Training Debriefing

The instructor will review all flight phases and defects in piloting technique with the student, and will offer all the necessary suggestions to improve the student's flying proficiency.
The student flying solo will report to his instructor, giving detailed information on his flight mission which will then be commented by the instructor.

PART TWO

VISUAL FLIGHT



PART TWO - CHAPTER IV

GROUND OPERATIONS

TABLE OF CONTENTS

Title	Page
General	4-1
Ground Operations	4-1
Minimum Distances between Aircraft during Taxiing	4-2
Lineup	4-4
Return to Parking Area After Landing	4-4
Parking Crew Signals	4-5

1. GENERAL

Ground operations are the maneuvers required to take the aircraft from the parking area onto the runway for the takeoff roll and, after landing completion, back to the parking area.
The aircraft is headed by the pilot by use of the engine power, the rudder pedals and the brakes.
The simplicity of these operations, compared to those following the takeoff phase, sometimes leads the pilot to be less alert to the general behaviour of the aircraft on the ground. Bear in mind that hazards during taxiing are more numerous than it may be expected.
Ground operations should always be authorized by the TWR on the GROUND (GND) frequency.
Maneuvers in proximity of the parking area are to be carried out by following the visual signals from the groundcrew personnel.
Taxiing speed must be moderate along the taxiways and very low in the parking area.

2. GROUND OPERATIONS

a. Leaving the Parking Area

When clearance to taxiing is obtained from the TWR on the "GND" frequency and after checking that the adjacent area is clear, proceed as follows:

- engage the nosewheel steering and check the associated light for illumination;
- maintain the aircraft braked by pressing on the rudder pedals;
- have chocks removed from the wheels;
- release the parking brake;
- increase engine power to 65% RPM;
- await for the crew chief to confirm that the way is clear;
- release the brakes to allow the aircraft to attain the correct maneuver speed;
- retard the throttle to "IDLE" slightly before reaching the "taxi line" and apply the rudder in the direction of the turn.

b. Taxiing

Taxiing is carried out along the taxiway centerline by suitably actuating the rudder pedals. Taxi with the throttle mainly at "IDLE". Increase power or use the brakes, as required, to maintain the prescribed safety speed. While taxiing behind other aircraft, maintain a distance of not less than 50 m from the preceding aircraft.
Use brakes only to slow down or to stop and not to head the aircraft. Optimum visibility permits a safe taxiing provided that the pilot who has control of the aircraft looks out. Checks that are to be carried out by concentrating the attention inside the cockpit will require that the aircraft be stopped or the aircraft control left to the other pilot.

c. Taxiing with Steering Failure or Simulated Steering Failure.

In case of a steering failure, taxiing can be carried out by holding the rudder centered and applying the brake in the desired direction of turn.
On approaching a turn, increase power as sufficient to oppose the reduction of speed caused by the directional use of the brakes and release the brake intermittently to prevent wear and overheating of the tires and brake discs.
During taxiing without steering and in presence of crosswind, the aircraft has a tendency to head upwind. Slight deviations of the aircraft from the taxiway centerline are permitted to avoid a continuous action on the brakes. The deviation will be controlled by the pilot by using the brake required to head the aircraft in the direction opposite to wind direction and then allowing the wind to return the aircraft to the initial direction. The aircraft will thus run a zigzag path (fig. 4-1).
When carrying out taxiing and pre-lineup checks, be always alert to the aircraft behaviour.

d. Radio Calls during Taxiing

Pilot: Jumbo GND this is Lion eight-two - TAXIING

Ground: Lion 82 cleared for runway one-four QNH 998 decimal 6, temperature one-seven, time check two-five, over.

Pilot: Eight-two roger. Runway one-four; QNH 998 decimal 6; one seven; two-five, out.

After the taxiing checks, turn to the OPS channel and request the Base Operation room to assign an operation area:

Pilot: Jumbo Operations, Lion eight-two, operation area

OPS: Lion eight-two, area seven

Pilot: Roger, area seven for Lion eight-two.

Then return to the GND frequency.

3. MINIMUM DISTANCES BETWEEN AIRCRAFT DURING TAXIING

- 50 meters between isolated aircraft which must still taxi on the taxiway centerline.

- 30 meters between formation aircraft which, during taxiing, must take up staggered positions with respect to the taxiway centerline.

3. FROM THIS POSITION THE WIND WILL BRING THE AIRCRAFT BACK TO POSITION 1.

2. APPLY BRAKES TO REACH AND SLIGHTLY OVERTAKE THE CENTERLINE.

1. THE AIRCRAFT INITIALLY ALIGNED WITH THE TAXIWAY CENTERLINE TENDS TO HEAD INTO THE WIND.

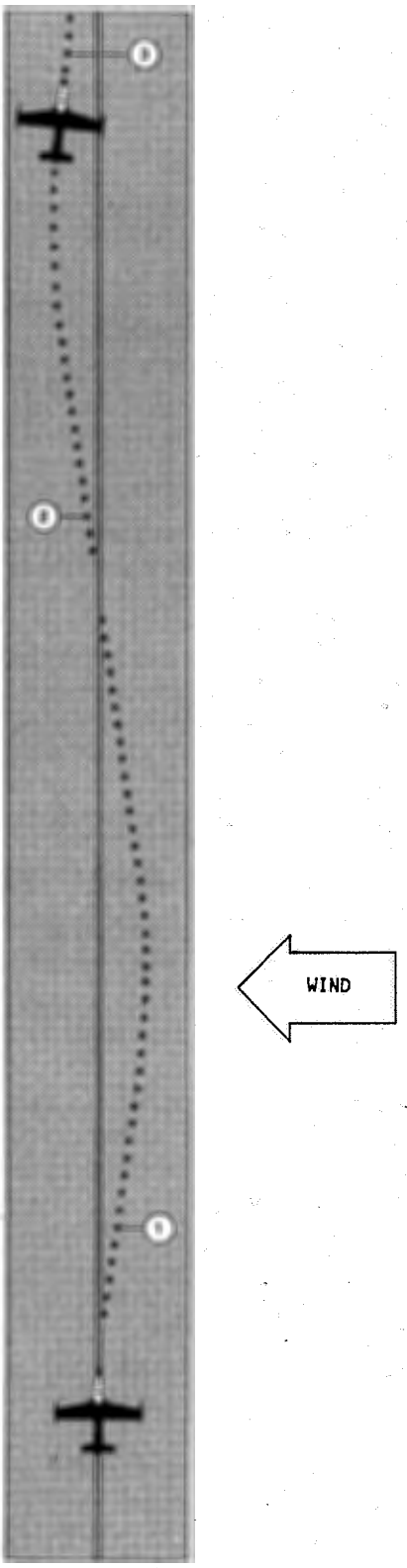


Figure 4-1. No Steering Taxi Under Crosswind Conditions

NOTE

Aircraft fitted with underwing stores must always taxi along the taxiway centerline.
Prior to requesting the runway, lineup make sure that there are no aircraft on landing (from the break onwards), or aircraft present on the runway.

CAUTION

When taxiing at short distance behind another aircraft, the oxygen diluter lever must be set to 100%.

In proximity of the holding point carry out the checks prescribed in the "Pilot's Check List".

4. LINEUP

WARNING

For no reason must the aircraft get over the white stop line on the lane and taxi onto the runway without clearance from the TWR.

Prior to requesting clearance for lineup, make sure that there are no aircraft on the runway or on landing. If holding is necessary, move to the side of the taxiway centerline to allow other aircraft taxiing behind you to take up alternate positions.

a. Standard Radio Calls

Pilot: Jumbo TWR, this is Lion eight-two. Canopy locked. Lineup.

TWR: Lion eight-two, cleared; (or), Hold; (or) Lineup after passage of aircraft on final.

Pilot: Lion eight-two, ...(or) WILCO, which means: I will comply (or) "Lion eight-two - Holds".

The aircraft usually enters the runway in proximity of the Mobile Control Post (MOBILE) which also has the task to monitor that the aircraft entering the runway are in the following conditions:

- speedbrake in
- flap T/O
- canopy closed
- no signs of fuel or other fluid leaks, no flagged safety pins installed and no doors open.

If required, the mobile control takes action via radio.
Lineup must take place on the runway centerline, or on the centerline of the left or right part of the runway as set forth in the procedures.
Do not take up any intermediate position.
The engine test prior to takeoff is part of the "takeoff phase" and will be treated in the following chapter.

5. RETURN TO PARKING AREA AFTER LANDING

Engage steering ("STEER" light on) prior to turning onto the taxiway. Switch off the landing light (if on) and the taxi light if not required.

Enter the taxiway at low speed and stop after 50 meters to insert the seat safety pin and, if necessary, to lock the canopy in the partially open position and to open the "RAM AIR SCOOP".
Again check that the speedbrake and the flaps are retracted and perform the after landing checks as instructed in the "Checklist".
Taxi at idle power and pay attention not to cause or undergo FOD. Follow the same procedures and maintain the same distances as specified for taxiing prior to takeoff.
In case of steering failure (true or simulated), entrance into the parking area will require a sharper turn with use of the brakes. While making a turn in this manner, avoid applying the brakes excessively to one wheel to pivot the aircraft. This not only damages the tire, but will deflect the nosewheel to the full steering position, thus placing excessive strains on the steering mechanism and the leg.
Enter the parking area by following the signals of the Crew Chief.
Apply the brakes and insert the parking brake.

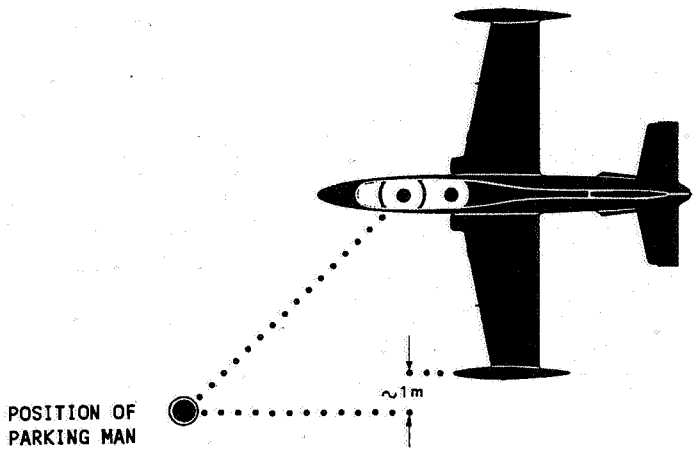
NOTE

See "Signals from the parking crew" at para 6.
Fully open the canopy only when the aircraft has stopped, better if the engine is shut down.

Once the specialist has applied the chocks to the wheels, disengage the parking brake.
Shut down the engine and carry out the checks listed in the "Checklist".
Leave the aircraft still wearing the helmet (never place the helmet on the canopy or the instrument panel), then take helmet and garters off.
Immediately fill in the aircraft logbook.
While recording the flight data, bear in mind that:
The departure and arrival times are to be approximated to the nearest five minutes above or below, and further five minutes are to be added for taxiing. (See instructions in the "AIRCRAFT LOGBOOK").
Defects encountered during flight are to be entered in the "AIRCRAFT LOGBOOK".

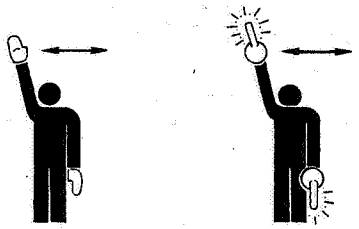
6. PARKING CREW SIGNALS

The signals from the Crew Chief or the parking man to the pilot to indicate the manoeuvres that he must carry out are standardized and identical for all NATO countries (NATO AIR-STD-44/42A).
ICAO, too, has adopted a few standard signals to direct the ground manoeuvres of civil aircraft.
These standardized signals are performed by the personnel assigned to direct the aircraft ground movements and manoeuvres by using the hands, or two flags, or two wands or two flashlights.
The parking crew will operate by facing the aircraft and standing straight in front of the L.H. wingtip, well in sight of the pilot (fig. 4-2).



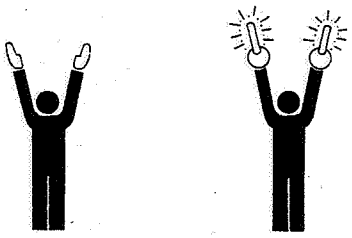
1. ATTENTION - I SHALL GIVE FURTHER INFORMATION

CALL PILOT'S ATTENTION BY RAISING THE RIGHT ARM VERTICALLY, WITH HAND OPEN AND PALM TOWARD THE AIRCRAFT, AND WAVING THE ARM SLOWLY TO RIGHT AND TO LEFT.



2. PARK HERE

ARMS RAISED VERTICALLY, WITH HANDS OPEN AND PALMS INWARD.



3. CONTINUE TO NEXT PARKING MAN

RIGHT OR LEFT ARM DOWN ALONG THE BODY. THE OTHER ARM IS MOVED HORIZONTALLY AT WAIST LEVEL, WITH HAND OPEN TO INDICATE DIRECTION OF NEXT PARKING MAN.

4. COME FORWARD

BOTH ARMS RAISED AND SLIGHTLY APART. HANDS OPEN AND PALMS AFT. MOVE ARMS TO-AND-FRO SLOWLY AND REPEATEDLY.

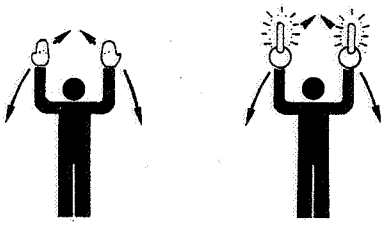


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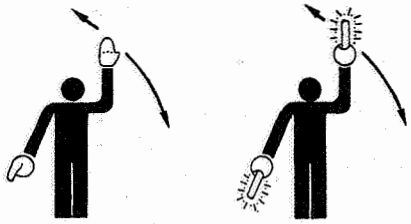
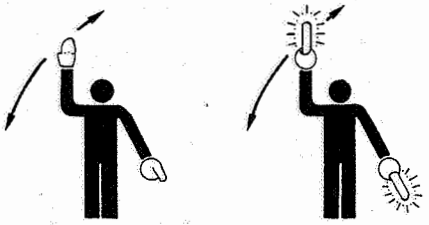
Figure 4-2. Ground Maneuvers - Signals from Parking Main to Aircraft (Sheet 1 of 5)

5. TURN

a. TO LEFT - RIGHT ARM POINTING DOWN TO THE RIGHT. LEFT ARM, WITH HAND OPEN AND PALM TOWARD THE FACE, RAISED AT HEAD LEVEL. MOVE HAND BACK AND FORTH REPEATEDLY.
FAST MOVEMENTS WILL INDICATE A SHARPER TURN.

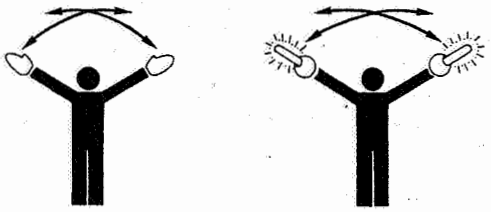


b. TO RIGHT - LEFT ARM POINTING DOWN TO THE LEFT. RIGHT ARM, HAND OPEN AND PALM TOWARD THE FACE, RAISED AT HEAD LEVEL. MOVE HAND BACK AND FORTH REPEATEDLY.
FAST MOVEMENTS WILL INDICATE THAT A SHARPER TURN IS REQUIRED.



6. STOP

ARMS RAISED AND REPEATEDLY CROSSED WITH HANDS OPEN. THE FASTER THE MOVEMENT, THE MOST URGENT THE NEED TO STOP.



7a. APPLY PARKING BRAKE

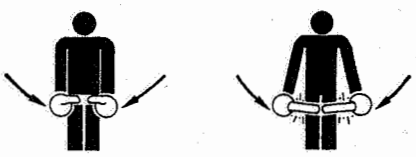
RIGHT FOREARM IN HORIZONTAL POSITION WITH HAND AT CHEST LEVEL AND FINGERS EXTENDED.
CLOSE FINGERS REPEATEDLY INTO A CLENCHED FIST.

7b. REMOVE PARKING BRAKE

RIGHT FOREARM IN HORIZONTAL POSITION AT CHEST LEVEL WITH CLENCHED FIST.
EXTEND THE FINGERS ALL OF A SUDDEN.

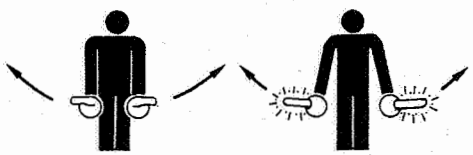
8a. WHEEL CHOCKS IN PLACE

ARMS HELD DOWN VERTICALLY WITH CLENCHED FISTS, THUMBS OUT AND POINTING TO EACH OTHER. MOVE THE HANDS TO BRING THE THUMBS CLOSE UNTIL THEY TOUCH.



8b. WHEEL CHOCKS REMOVED

ARMS HELD DOWN VERTICALLY WITH CLENCHED FISTS, THUMBS EXTENDED AND POINTING OUTWARD. MOVE THE ARMS OUTWARD ALL OF A SUDDEN.



391-1093

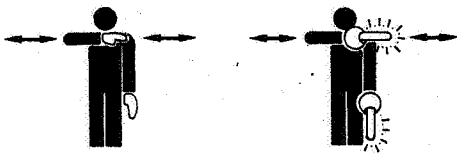
Figure 4-2. Ground Maneuvers - Signals from Parking Main to Aircraft (Sheet 2 of 5)

9. START THE ENGINE (OR ENGINE No. ....)

RAISE THE LEFT ARM VERTICALLY, AND THEN EXTEND ONE, TWO, THREE, ETC. FINGERS TO INDICATE THE NUMBER OF THE ENGINE TO BE STARTED.
RIGHT HAND TURNED IN A CIRCLE AT HEAD LEVEL.
ENGINES ARE NUMBERED LEFT TO RIGHT (No. 1 IS THE LEFT OUTBOARD ENGINE).

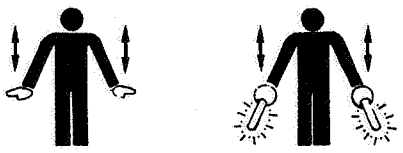
10. SHUT-DOWN ENGINE (ENGINES)

LEFT ARM HELD VERTICALLY DOWN. RIGHT HAND IN HORIZONTAL POSITION IN FRONT OF THE THROAT.
SIDEWARD MOVEMENT OF THE EXTENDED HAND.



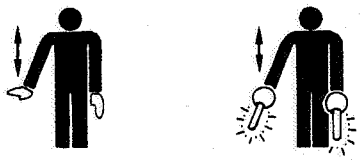
11. SLOW DOWN

TAXI SLOWLY: ARMS HELD LOW AND SLIGHTLY APART. HANDS WITH PALMS OPEN AND FACING THE GROUND.
CONTINUOUS SHORT UP AND DOWN MOVEMENT OF THE HANDS.



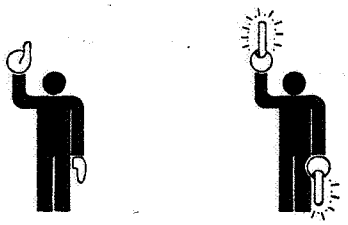
12. BRING ENGINE TO IDLE

ONE ARM HELD DOWN VERTICALLY, THE OTHER (ON THE SIDE OF THE CONCERNED ENGINE), WITH HAND OPEN AND PALM FACING DOWNWARD.
CONTINUOUS SHORT UP AND DOWN MOVEMENT OF THE HAND.



13. AIRCRAFT CLEARED TO MOVE

LEFT ARM HELD DOWN VERTICALLY ALONG THE BODY. RIGHT ARM HELD UP AT HEAD LEVEL WITH CLENCHED FIST AND THUMB UP.



391-1094

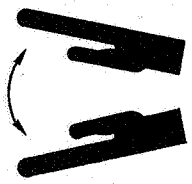
Figure 4-3. Ground Maneuvers - Signals from Parking Main to Aircraft (Sheet 3 of 5)

14. CHECKED, EVERYTHING OK

ARM UP AT HEAD LEVEL, WITH THUMB AND FOREFINGER FORMING AN O.

15. EXTEND FLAPS

ARMS EXTENDED FORWARD AT CHEST LEVEL.
HANDS OPEN, SUPERIMPOSED, WITH PALMS FACING. WHILE HOLDING WRISTS IN CONTACT, OPEN THE HANDS ALL OF A SUDDEN.

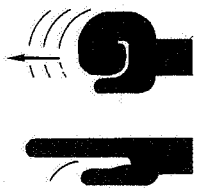


16. RETRACT FLAPS

ARM EXTENDED FORWARD AT CHEST LEVEL.
HANDS SUPERIMPOSED WITH PALMS FACING, WRISTS IN CONTACT AND HANDS SET APART. MOVE HANDS IN CONTACT ALL OF A SUDDEN.

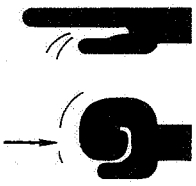
17. EXTEND SPEEDBRAKE

ONE ARM ONLY EXTENDED FORWARD HORIZONTALLY AT CHEST LEVEL. FIST CLENCHED WITH FINGERS DOWNWARD.
OPEN THE FIST ALL OF A SUDDEN.



18. RETRACT SPEEDBRAKE

ONE ARM ONLY EXTENDED FORWARD HORIZONTALLY AT CHEST LEVEL. HAND OPEN PALM TURNED DOWNWRD.
CLOSE FINGERS IN A CLENCHED FIST ALL OF A SUDDEN.



19. EXTERNAL POWER SUPPLY CONNECTED

HANDS HELD HORIZONTALLY AT FACE LEVEL. PALMS TURNED DOWNWARD. CLAPS FINGERS OF RIGHT HAND BETWEEN THE THUMB AND THE OTHER FOUR FINGERS OF THE LEFT HAND (TO INDICATE CONNECTION), OR RELEASE (TO INDICATE DISCONNECTION).

391-1095

Figure 4-4. Ground Maneuvers - Signals from Parking Main to Aircraft (Sheet 4 of 5)

20. NOSE-UP TRIM

LEFT HAND AT FACE LEVEL WITH PALM TURNED DOWNWARD. FINGERS JOINED AND EXTENDED. WITH THE THUMB OF THE RIGHT HAND EXTENDED (THE OTHER FINGERS CLENCHED INTO A FIST), BEAT REPEATEDLY ON PALM OF LEFT HAND.

21. NOSE-DOWN TRIM

LEFT HAND EXTENDED HORIZONTALLY AT FACE LEVEL WITH PALM TURNED DOWNWARD.
WITH THE THUMB OF THE RIGHT HAND DOWN (THE OTHER FINGERS CLENCHED INTO A FIST), BEAT REPEATEDLY ON THE BACK OF THE LEFT HAND.

22. INSERT OR REMOVE EJECTION SEAT SAFETY PIN

HANDS AT CHEST LEVEL WITH ARMS EXTENDED FORWARD. LEFT HAND CLENCHED INTO A FIST. THE THUMB OF THE RIGHT HAND GOES INTO (INSERT) OR OUT (REMOVE) THE CLENCHED FINGERS OF THE LEFT HAND. THE OTHER FINGERS OF THE RIGHT HAND ARE CLENCHED INTO A FIST.

23. OPEN THE CANOPY

RIGHT ARM HELD DOWN VERTICALLY. LEFT FOREARM HORIZONTAL WITH HAND CLENCHED INTO A FIST. ROTATE THE FOREARM UP WITHOUT MOVING THE ELBOW.

24. CLOSE THE CANOPY

RIGHT ARM HELD DOWN VERTICALLY. LEFT ARM BENT WITH FOREARM UP AND HAND CLENCHED INTO A FIST. ROTATE WITHOUT MOVING THE ELBOW UNTIL THE HAND REACHES THE HORIZONTAL POSITION.

391-1096

Figure 4-5. Ground Maneuvers - Signals from Parking Main to Aircraft (Sheet 5 of 5)

PART TWO - CHAPTER V

TAKEOFF, CLIMB AND LEVEL OFF

TABLE OF CONTENTS

Title	Page
Takeoff	5-1
Acceleration	5-3
Climb	5-3
Level Off after Climb and Straight Flight	5-6

1. TAKEOFF

Takeoff is the sequence of the manoeuvres from brake release to aircraft lift-off.
Pre-takeoff checks and takeoff are to be accomplished as specified in the "Checklist".
The radio calls to be used are as follows:

- Pilot: Lion eight-two requires clearance for takeoff
- TWR: Eight-two cleared (or) eight-two hold
- Pilot: Eight-two holds

If the wind is significant, i.e. it has a velocity greater than 10 knots, the TWR for example will add: crosswind, from right, 12 knots (direction referred to the runway centerline).
For the length of the takeoff roll, refer to the "Performance Data Manual" PI 1T-MB339A-1-1.

a. Takeoff Roll

Unless otherwise instructed, an isolated aircraft will takeoff at 100% RPM. Prior to brakes release, check again: RPM 100% EXH TEMP < 756°C - Longitudinal TRIM centered - "STEER" light out.
In the training configuration (aircraft clean, crew of two, full internal fuel = 4400 kg mass), the rotation speed is 85 KIAS.
Until this speed has been attained, the control stick will be left in neutral position.
Figure 2-4 in the FM is self-explanatory.
See para 1.c for the possible use of steering during takeoff and landing.
Maintain directional control by moderately using the brakes up to 45-50 KIAS; in particular apply brakes on one wheel only and ease off when the lineup position is attained.
From this speed onwards, direction can be maintained with the rudder if no strong crosswind is present.

b. Crosswind on Takeoff

In case of takeoff with crosswind and steering disengaged, the aircraft will have a tendency to head into the wind. This must be counteracted with the brake, then with opposite rudder application. The wind action will concurrently tend to lift the upwind wing.
Control stick deflection in the direction of the wind will give "crossed" controls during the takeoff roll.

c. Use of Steering Control on Takeoff and Landing

The steering control is not certified for use during takeoff and landing since it is not provided with a "Fail Safe" electrical control which automatically disengages the steering when the positions of the rudder pedals and of the nosewheel are not consistent (because of an electrical, hydraulic or mechanical failure).
A malfunction of this type is extremely rare but possible.
Steering can therefore be used on takeoff and landing (i.e. at high speed) only to prevent or correct a condition of loss of directional control, such as a blown tire, a strong crosswind or a high asymmetrical load. If takeoff is accomplished without steering, do not engage the steering control during the takeoff roll; on the contrary use it in case of aborted takeoff if the aircraft tends to go out of control.
In this case engage steering with the rudder pedals centered to avoid abrupt turns on steering engagement.

d. Rotation and Lift-off

During the takeoff roll, the efficacy of the rudder pedals and control stick increases with the square of IAS. At a speed close to the lift-off speed, minor control deflections will produce the required attitude changes. Even the corrections required to counteract crosswind will become very small; it is however necessary to neutralize the ailerons when initiating back pressure.
From 85 to 90 KIAS, perform "rotation" by gently applying aft stick to raise the nose 7° above the horizon and reapply forward stick (just a little) not to exceed this attitude.
The aircraft will fly off the ground at approx. 100 KIAS and will start drifting with the wind if a strong crosswind is present.
Hold the wings level and the nose 7° above the horizon.
At AGL altitude and safety speed (30 ft/120 KIAS), apply the brakes and retract the landing gear. Correct drift to maintain the flight path towards the envisaged "acceleration checkpoint", by banking the aircraft not more than 15° upwind and then levelling the wings.
Retract the flaps (min 120, max 150 KIAS) and carry out the specified post-takeoff checks.
After flap retraction, oppose the aircraft tendency to settle back onto the ground by a coordinated use of the control stick and the trim.

e. Attainment of "Acceleration Checkpoint"

Maintain 100% RPM in slight climb (from 1000 to 1500 FPM on the vertical velocity indicator).
In case of takeoff at "maximum climb gradient" for obstacle clearance, maintain: flap T/O; AOA 0.65; 120 KIAS.
While the aircraft climbs straight ahead and accelerates from 120 to 250 KIAS, check that the oxygen diluter lever is at "N" (normal) and perform the post-takeoff radio call as required.
Trim the aircraft while it accelerates.

NOTE

To trim = to adjust and balance the aircraft by zeroing the forces applied to the control stick and/or the rudder pedals by use of the TRIM controls.
This neologism is now of common use.

2. ACCELERATION

a. Acceleration to Leave the Circuit (fig. 5-1)

After flap retraction maintain the attitude to allow the aircraft to reach 1500 ft AGL and 250 KIAS if the climb is to be performed at constant indicated airspeed (see "Performance Data Manual").
This "climb start point" is normally reached after one minute and two nautical miles from takeoff.
For military power climb, allow the aircraft to accelerate to 275 KIAS.
At the climb start point, reduce power to "intermediate rating", i.e. 98% RPM.

b. Acceleration to Hold the Circuit (fig. 5-2)

After takeoff, maintain a 7° nose-up pitch attitude as for normal acceleration.
At 250 KIAS, reduce RPM to 82% and continue climb. At 1300 ft AGL, i.e. 200 ft prior to level-off, decrease the rate of climb and level off at 1500 ft AGL/250 KIAS.
Adjust RPM and TRIM. Turn onto the circuit at the envisaged lead point.

3. CLIMB

Three different types of climb are envisaged to reach the assigned mission or navigation altitude, namely:

- Climb for visual training flights at 250 KIAS and 98% RPM maintained constant up to level off.
- Military power climb at constant IAS and constant MACH.
- Long range military power climb at variable airspeed.

For any type of climb it must be borne in mind that the attitude changes are obtained almost instantaneously whereas the deriving speed changes take place after several seconds. Therefore, attitude will be slightly changed during the climb to correct speed and a time allowance envisaged for the slower speed change.

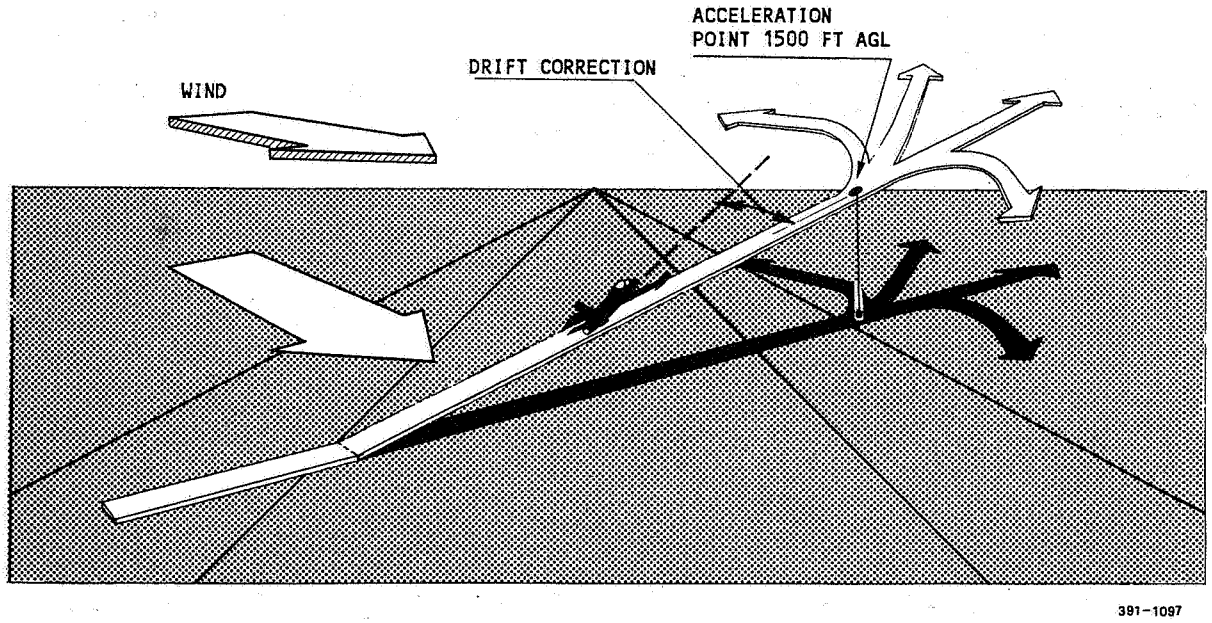
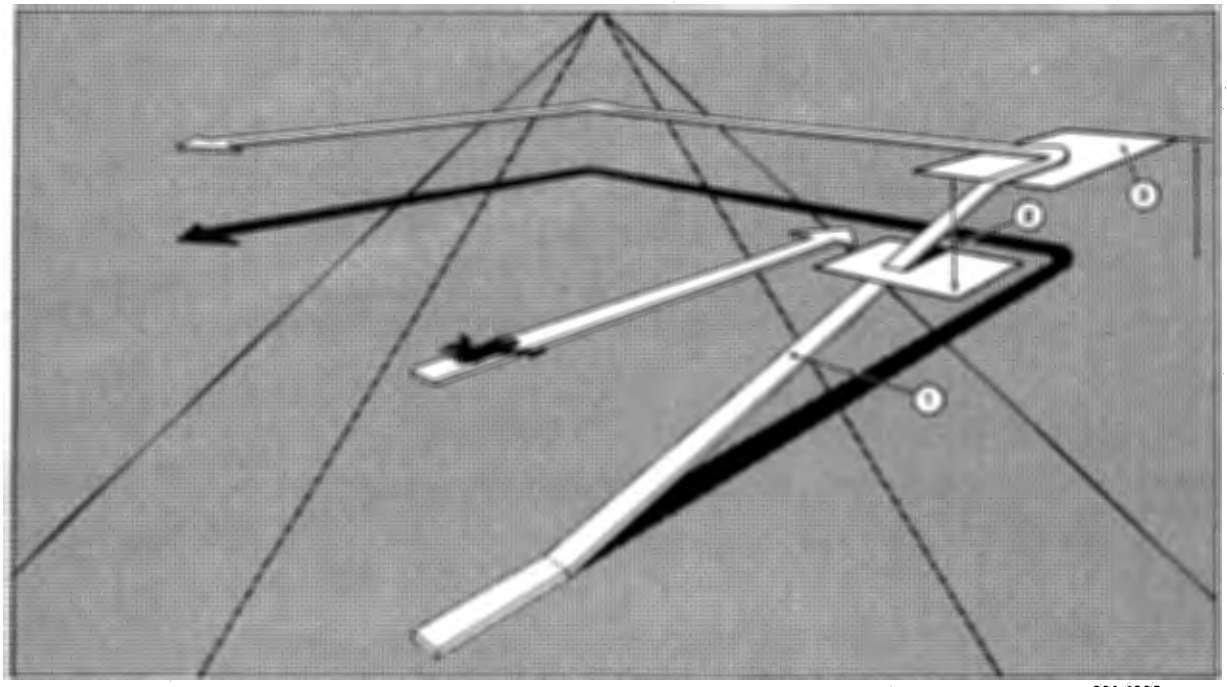


Figure 5-1. Acceleration Point and Climb Start



1. 250 KIAS 82% RPM
2. LEAD POINT TO LEVEL-OFF: 200 FT
3. 1500 FT 230 KIAS

Figure 5-2. Acceleration to Hold the Circuit

a. Climb at Constant IAS

At the acceleration checkpoint, reduce power to 98% RPM.
Maintain 250 KIAS with a small nose-up attitude change.
Then make a turn to leave the pattern, with 30° bank and 90° range in the direction specified by the Traffic Regulations. Checks are made every 10 000 ft.

b. Military Power Climb at Constant IAS/MACH

This is the type of climb recommended for normal instrument and navigation flights. At the acceleration checkpoint, reduce power to 98% RPM. Establish and maintain a speed of 250 KIAS with a small nose-up attitude change until a 0.55 IMN is attained (at approx. 20 000 ft), which is to be maintained up to level off.
FL420 is recommended for the maximum range in clean configuration. The climb with the aircraft in "ferry" configuration for transfer flights with underwing tanks installed, will be carried out at 225 KIAS; this speed will be maintained until reaching 0.50 IMN, which will then be constant for the whole climb.

FL370 is recommended in standard day for the maximum range in "ferry" configuration. It is however necessary to refer to the "Performance Data Manual".

c. Military Power Climb at Decreasing IAS, "Long Range"

A climb at variable IAS offers so little advantages with respect to a climb at constant IAS/MACH that its use is unrecommended except for flights performed at the extreme range limit.

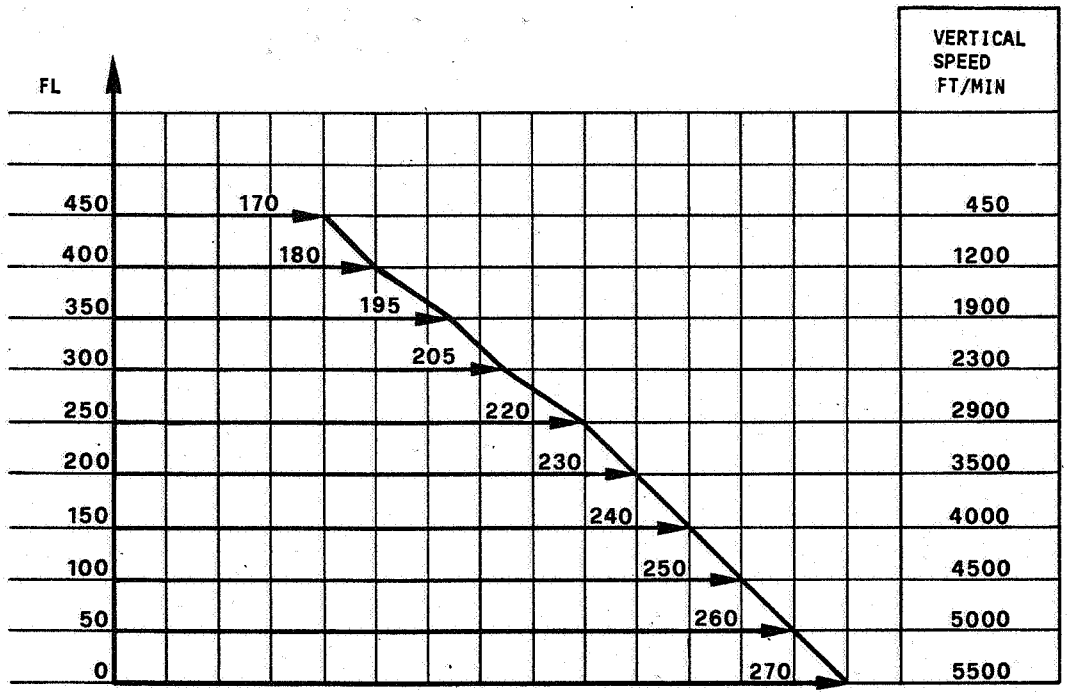


Figure 5-3. Climbing Vertical Velocity - Military Power Climb

With clean aircraft: 98% RPM and 270 KIAS at sea level. Decrease IAS by two knots every 1000 ft by very smoothly changing the pitch attitude in order to have (fig. 5-3).
The military power climb with the aircraft in "ferry" configuration and 98% RPM must be carried out with the following climb speed schedule, in standard day (fig. 5-4).
For non-standard day conditions, refer to the "Performance Data Manual".

d. Climbing Turns (fig. 5-5)

Even if the aircraft has an excellent forward and downward visibility, it is wise to perform a few safety turns (or area clearing turns) during the climb in order to more effectively check the surrounding space.

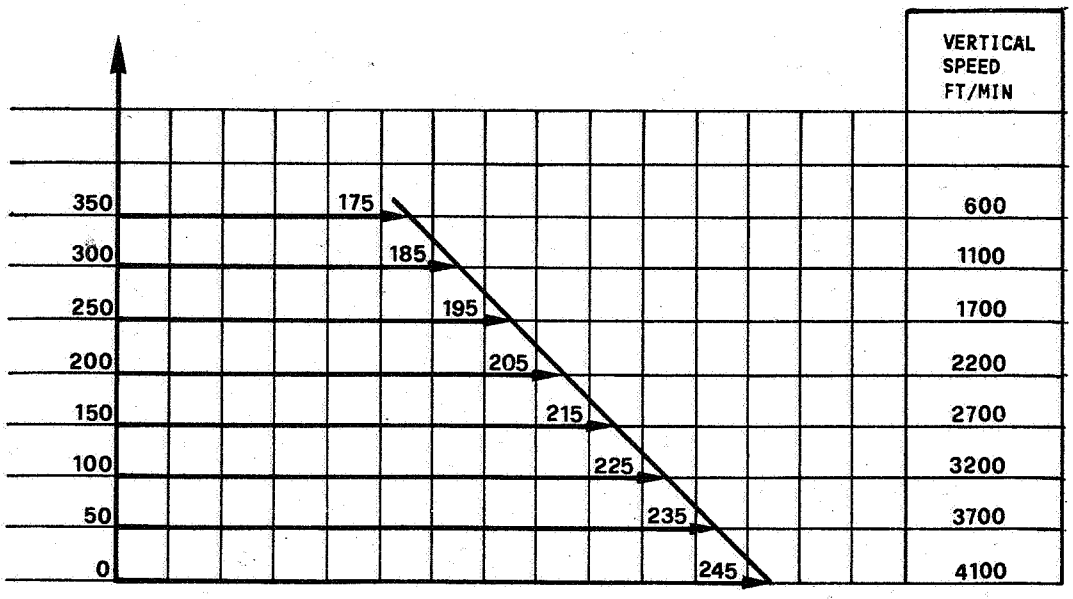


Figure 5-4. Climbing Vertical Velocity - Constant IAS/MACH

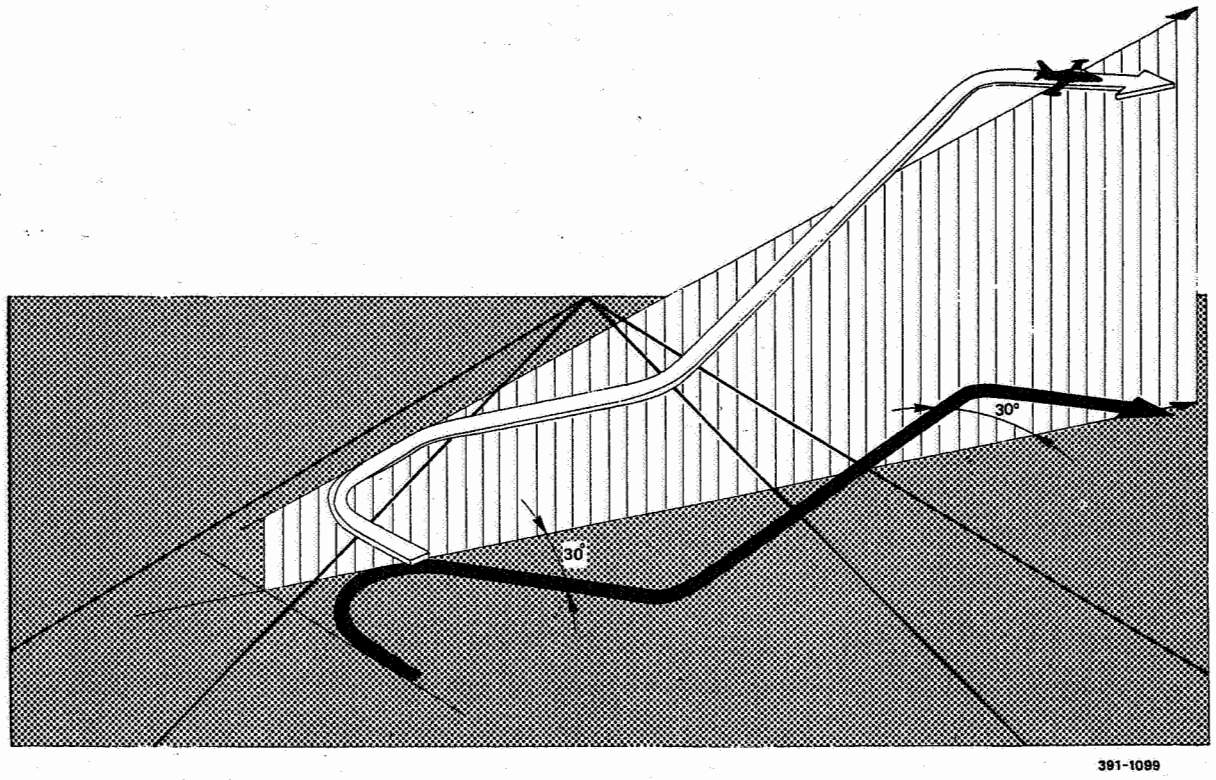


Figure 5-5. Climbing Turns

These turns are performed with a max bank of 30° by turning not more than 30° to the right and the left of the selected climb path.
These turns must be alternated to straight segments flown with wings level. The technique for the performance of climbing turns is described in para "light turns" of Chapter VI.

4. LEVEL OFF AFTER CLIMB AND STRAIGHT FLIGHT

The attitude change that takes the aircraft from the conditions of climb to a level flight condition is called level-off.
For both the previously described types of climb, the level-off technique is the same and rests on a cross-check of the altimeter (primary instrument) and the vertical velocity indicator (fig. 5-6).
Level-off is to be started using a lead point to the desired level-off altitude that is 10% of the vertical velocity read on the indicator.
Lower the nose of the aircraft down very gently to stabilize it with a smooth and even manoeuvre "in level flight".
There are three different types of level-off as a function of the climbing speed (IAS) and of the IAS to be maintained in level flight:

a. Climbing IAS Equal to Level Flight IAS

Concurrently with the level-off manoeuvre, reduce power as required to maintain the IAS in level flight.

b. Climbing IAS Lower than Level Flight IAS

Change attitude and level-off without reducing power.
When the IAS will be 5 knots less than the IAS required for level flight, retard the throttle to the RPM% required to maintain the established IAS.

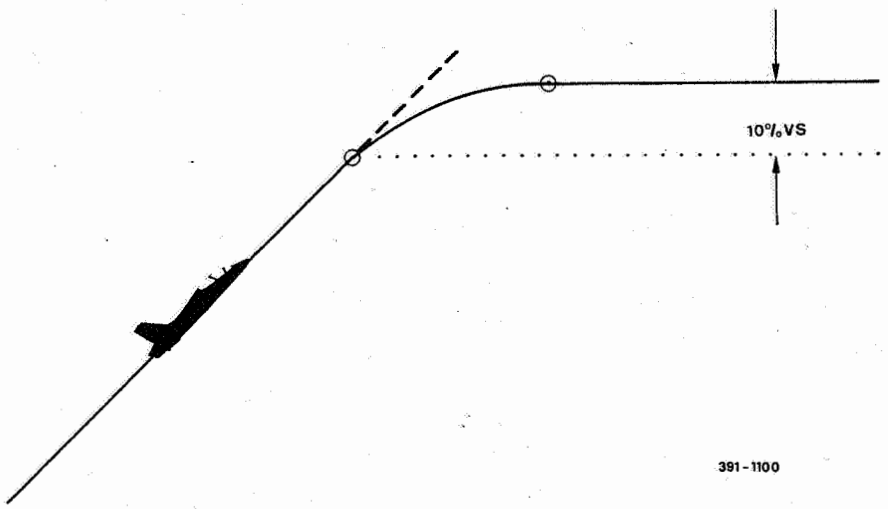


Figure 5-6. Leveling After Climb

c. Climbing IAS Greater than Flight Level IAS

The lead given to power reduction with respect to the attitude change will be proportional to the difference between the climbing speed and the level-off speed.

Approximately retard the throttle to the established RPM one second before for every two knots of difference between the climbing IAS and the level flight IAS.
After level-off, carry out the checks (see FM, Section II).

NOTE

The climbing vertical velocity at intermediate RPM (98%) is the same both for the military power climb and the climb at constant IAS/MACH (fig. 5-3 and 5-4).

PART TWO - CHAPTER VI

VISUAL FLIGHT NON ACROBATIC

TABLE OF CONTENTS

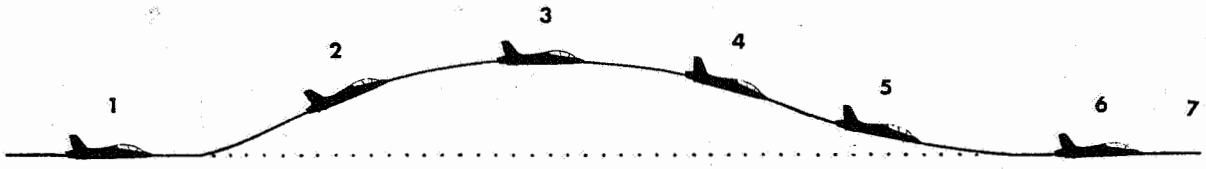
Title	Page
Straight and Level Flight	6-1
Piloting Technique	6-2
Turns	6-5
Airspeed Changes	6-8
Climb or Descent at Costant IAS, Constant Vertical Speed	6-9
Stalls	6-9
Slow Flight	6-19
Compressibility	6-21

1. STRAIGHT AND LEVEL FLIGHT

This is the flight performed by maintaining constant values of:

- Altitude
- Airspeed
- Magnetic Heading

The main instruments to be referred to are therefore:
the altimeter, the airspeed indicator and the gyro compass, but most important is that you acquire the feel required to determine your position/attitude in relation to outside references by making a less and less frequent use of the instruments.
In other words the very simple straight-and-level flight can give the measure of the proficiency and feel of the student pilot.
The speed to be maintained for training purposes normally is 250 KIAS or Mach 0.5.
The technique to maintain the three parameters viz. heading (fig. 6-1), altitude and speed suggested only by experience, whilst the correction technique to return the aircraft to a flying condition conform to the three established parameters is as follows:



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1. AIRCRAFT LEVELLED OFF AT THE CORRECT ALTITUDE
2. AIRCRAFT CLIMBING. ERROR DETECTED
3. STOP THE ALTIMETER BY CHANGING ATTITUDE
4. CHANGE ATTITUDE TO DIVE
5. RETURN TO LEVEL ATTITUDE AT CORRECT ALTITUDE
6. AIRCRAFT IS LEVELLED AT THE DESIRED ALTITUDE
7. TRIM AS REQUIRED

Figure 6-1. Level Flight and Corrections

(1) Detection of error (ex. 50 ft more)

(2) Locking of error (Stop the altimeter and vertical speed indicator at zero)

(3) Correction opposite to error (altimeter going down/Vertical speed indicator indicating descent).

(4) Locking of correction (altimeter steady at the desired altitude).

2. PILOTING TECHNIQUE

Before describing the maneuvers and the technique used to perform the maneuvers, it is necessary to acquire a general knowledge of the piloting technique valid for either visual or instrument flying and applicable to any maneuver.

a. Feel, Visual and Instrument References

The "feel" viz. the sensations that reach your brain from the internal ear or the man-aircraft pressing feelings (bottom, back) is only a very limited piece of information for piloting. It is, in fact, of no use in a flight with no accelerations (normal, longitudinal, lateral). When the accelerations are small they are generally unperceived and let us not forget it, a small acceleration maintained constant in the time gives a sensation of no acceleration.
As a matter of fact, the "feel" is a function of the acceleration changes and is acquired and refined only after a long experience.
Without a visual reference or an instrument reference, piloting an aircraft is totally impossible.
Refer to the "Instrument Flying and Navigation Manual" PI AD-03-39A for the "false physical sensations." It is not true that the aircraft is piloted with the seat-of-the-pants sense. This sense is of little help and only in few cases.
Under the premise of this necessary clarification, let us establish the aircraft attitude and flightpath in the air.
From the observation of the outside world (or from the ADI information), and by superimposing the cabin elements over the visible horizon, the pilot will acquire the experience to evaluate:

- the attitude
- the attitude change
- the speed at which the attitude change takes place

A pilot properly seated in the front cockpit of the MB-339A (eye mid-way between the instrument panel cover and the windshield frame), with the aircraft in straight-and-level flight, will see the outside world as shown in figure 6-2.

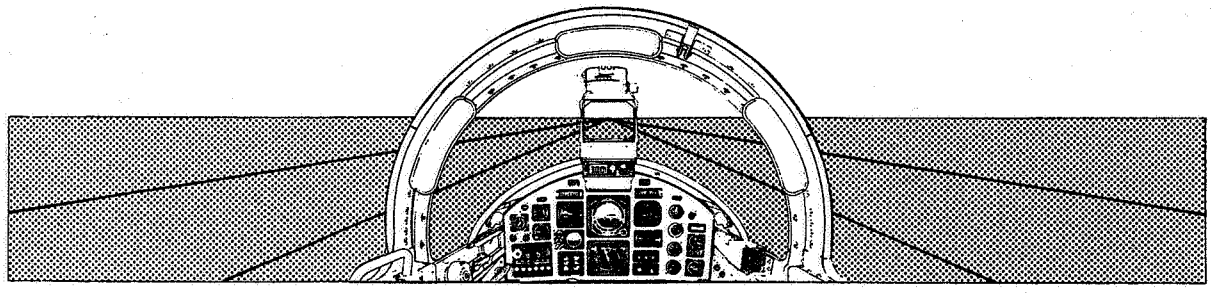


Figure 6-2. Horizon Line in Levelled-off Attitude

For the instrument control of attitude: altimeter stopped, vertical speed indicator at zero, ADI miniature aircraft levelled (adjust if required). If the hearth's horizon, apart from its position in relation to the reference, does not move, attitude is stabilized and may be the desired one or otherwise.

b. Actions on Flight Controls

The aircraft attitude is the first and simplest thing to control.
After a few flights, maintaining the attitude becomes instinctive, or it is better to say that the action on the controls to maintain the attitude becomes an automatic reaction of which the pilot is almost unaware.
The small pressures on the stick to maintain the attitude become instinctive.
The second experience is to turn from a "varying" attitude to a "stabilized" attitude and then return to the desired attitude.
The subsequent experience is to control the flight path through the attitude.
Remember that the control over the flightpath is very usefuel in flight and the attitude control is but a means to control the flightpath (together with the power control).
The subsequent phase of the experience is:
to cause changes in attitude, flightpath and speed in order to get and stabilize new parameters of flightpath, speed and, consequently, also of attitude.
Remember that to a stabilized attitude, be it level, banked, nose-high or nose-down, there practically corresponds a center-off and steady position of the controls.

The control deflection required to change the attitude is directly proportional to the variation rate of the attitude that it is desired to obtain and inversely proportional to the IAS square.
Remember that to pass from a stabilized to a "moving" attitude, you must go through a transitory angular acceleration phase.
This transitory regime is however rather short and we can say that the aircraft response to the attitude control is very prompt.
Even in extreme cases of aircraft roll at 150° per second, and in spite of the great inertia of the aircraft, the response to the controls (stabilized roll or roll recovery), is obtained in tenths of second.
The response in flightpath is slower than the attitude response but still sufficiently prompt.
The speed response either for flightpath or power changes is much slower.

c. Trimming

To "steady stabilized" attitudes there must correspond a balancing of the control stick by trimming which consists of:

- Visually controlling the "steady" attitude
- Momentarily stiffening the wrist to lock the control stick where it is.
- Relieving pressure on the grip by short bursts on the TRIM push-button, bearing in mind that the time between control operation and control response is more than 1 to 1,5 seconds.

d. Coordination

At high speeds the aircraft is very stable directionally and very responsive longitudinally; it is conversely poorly responsive longitudinally and very stable directionally at low speed.
For instance: a 1 degree change in pitch attitude gives a vertical speed

(vertical speed indicator) of 200 ft/min at 120 knots and 800 ft/min at 480 KTAS (300 KIAS at 30 000); a 3 °/sec turn is obtained with 18° of bank at 120 KIAS, but 72° of bank and 3 g at 200 KIAS are required at 30 000 ft (320 KTAS) for the same turn.
The MB-339A aircraft is designed and built so that the sole aileron input is sufficient to produce coordinated turns, viz. with the ball centered (differential movement of ailerons, large-sized fin, ventral strakes).
In practice the rudder pedals are used only for takeoff and in the last phase of the approach to landing.

e. Summary

Speed is controlled by power (RPM, throttle), the flightpath through attitude, viz. the outside world and the stick, with occasional though rather frequent cross-checks of the altimeter (or the vertical speed indicator) and the gyro-compass.
The procedure to turn from a heading-altitude-attitude-flightpath situation to another always consists of:

- detecting the attitude error (if present)
- removing the attitude error
- applying the control stick to obtain a new attitude in the desired direction (immediate effect)
- Locking the aircraft in the desired attitude
- Taking up the final attitude with a certain lead on the desired position (heading, altitude) but more smoothly
- Setting the controls to neutral and trimming to the final attitude.

The procedure to change or stabilize speed must take into account the mass component which is added to (or subtracted from) the thrust provided by the engine in descent (or climb) and above all must take into account the inertia due to the aircraft mass.
Apply or remove power several seconds before the moment required to stabilize speed, as specified later on. Even in visual flying, in some cases such as the high altitude flights with mist, presence of clouds in the surroundings, etc. it may be necessary to check the attitude on the ADI very often.
Remember that the ADI in the MB-339A has no precession errors and its accuracy is within ± half degree in roll and pitch in any circumstances.

f. Technique for Maintaining Attitudes

It consists of applying only the first part of the correction, namely:

(1) From level flight (longitudinally and/or laterally) return to level flight regardless of the occurred variations of altitude and heading.

(2) From turn flight: stop the aircraft tendency to dive or climb without correcting back to the desired altitude; then resume the selected bank.
A small or moderate amount of initial pressure should be applied to the control stick in the desired direction and relaxed as soon as the outside world which determines the attitude and the relevant indicator approach the desired values.
Then adjust the "trim".

g. Concurrent Errors in Altitude and Speed

There is often a correlation between altitude and speed errors.

(1) If altitude is above and speed is below the desired value, lower the aircraft nose smoothly to obtain an attitude suitable to reach the selected altitude.

(2) If altitude is above the desired value and speed is correct or above the desired value, reduce RPM %, lower the aircraft nose and then restore the RPM % to maintain the selected altitude and speed.

(3) If altitude is below and speed above the desired value, raise the aircraft nose smoothly to obtain an attitude suitable to reach the selected altitude.

(4) If altitude is below the desired value and speed is correct or below the desired value, increase the RPM % and raise the aircraft nose, then reduce the engine RPM once the selected altitude and speed are attained.

NOTE

In training flights the airspeed prescribed in level flight is 250 KIAS (at 15 000 ft approx. 85% RPM).

3. TURNS

Turns are coordinated maneuvers used to change the direction of the aircraft.
They require the coordination of the longitudinal control and power with the lateral control which determines the turn rate through the angle of bank.

Basing on the bank, turns can be distinguished into:

- shallow turns: up to 29°
- medium turns: 30° to 44°
- steep turns: 45° to 59°
- very steep turns: 60° to 90°

All these turns can be performed in level flight (constant altitude) climb or descent.
Except for the shallow turns, the aircraft angle of bank must be checked on the ADI.

a. Shallow Turns

The shallow turns are turns commonly used to restore the heading after measuring heading errors of less than 30°.
These turns are performed with a bank equal to the rate of correction that must be introduced (fig. 6-3).
To roll out of a turn, start bringing the wings level approximately when the attained heading value is the desired one ± 20% of bank.
Example: the aircraft heading is 050°, the desired heading is 069°. The shallow turn will therefore be 19°. Bank the aircraft 19° to the right (increase heading) and start wings level-off when the heading is (069° - 4°) = 065° (20% of 19° is 3,8°).

NOTE

These turns are normally called shallow turns and are characterized by a very smooth rollout.
The shallow turns are especially used in both visual and instrument final approach maneuvers and in airway flying.
They require neither pitch attitude nor power adjustments.

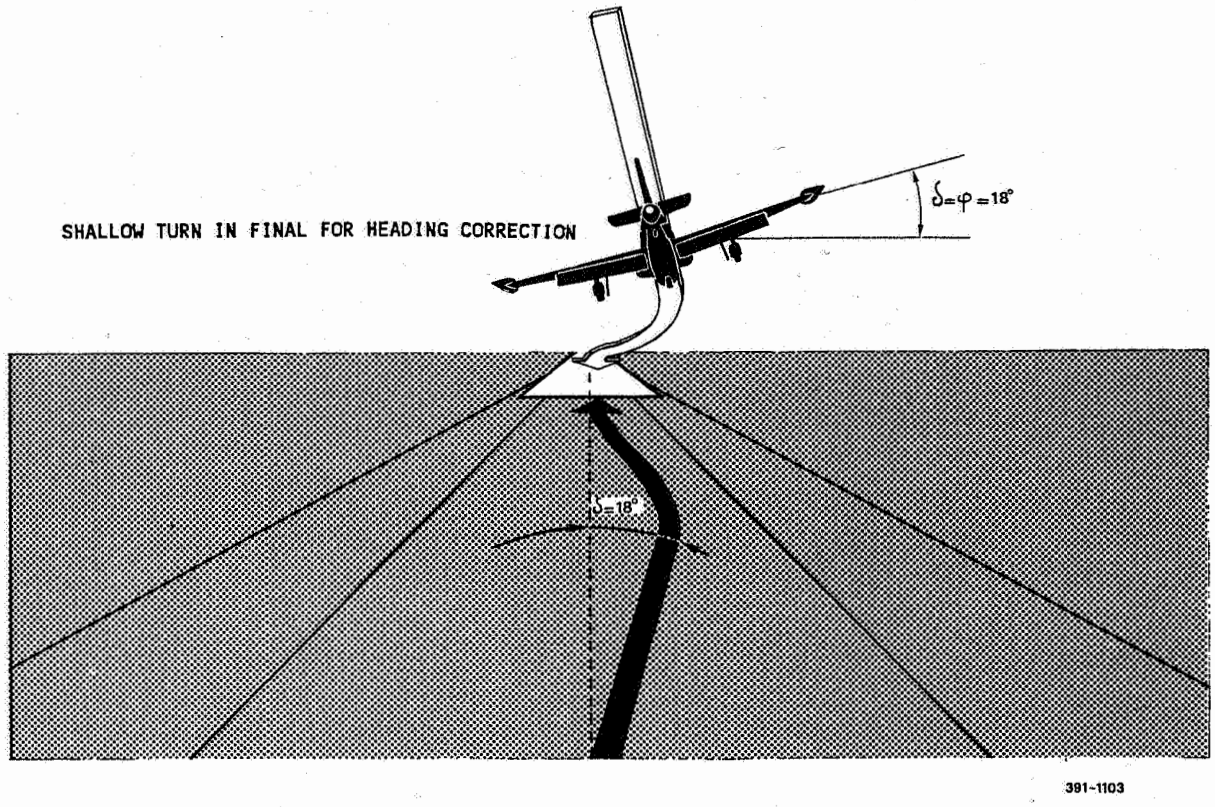


Figure 6-3. Shallow Turn

b. Medium Turns (fig. 6-4)

Medium turns are turns normally performed in "non-operational" instrument flying and in visual flying when a high rate of turn (abrupt change of direction) is not required and the tendency is to perform a precise and smooth maneuver.
Before beginning any turn, make sure that the surrounding area is clear (especially the area outside the turn), that the aircraft is trimmed and sufficient outside references are present.
Technique: apply lateral pressure on the control stick to bank the aircraft in the direction of the turn.
The aileron servo-control is fitted with an artificial feel device which creates stick forces proportional to the lateral deflections, thus giving the pilot the feel of the amount of stick angular displacement.
Experience will teach you to apply the correct amount of pressure on the control stick and the velocity at which you must move the stick laterally to obtain the desired rate of roll.
When the aircraft has almost attained the desired angle of bank, slowly return the aileron control to neutral so as to "stop" the visible horizon line on the selected bank; at the same time use back pressure to prevent the nose from lowering, still referring to the visible horizon.
Back pressure must be proportional to the bank and such as to compensate for the decrease in vertical lift and the effect of the "g" load.

c. Steep Turns (fig. 6-5)

Steep turns are the most used in maneuvered visual flying (circuit, holding of areas, safety turns, etc.).
Technique: in steep turns the back pressure on the stick must be increased only slightly with respect to medium turns.

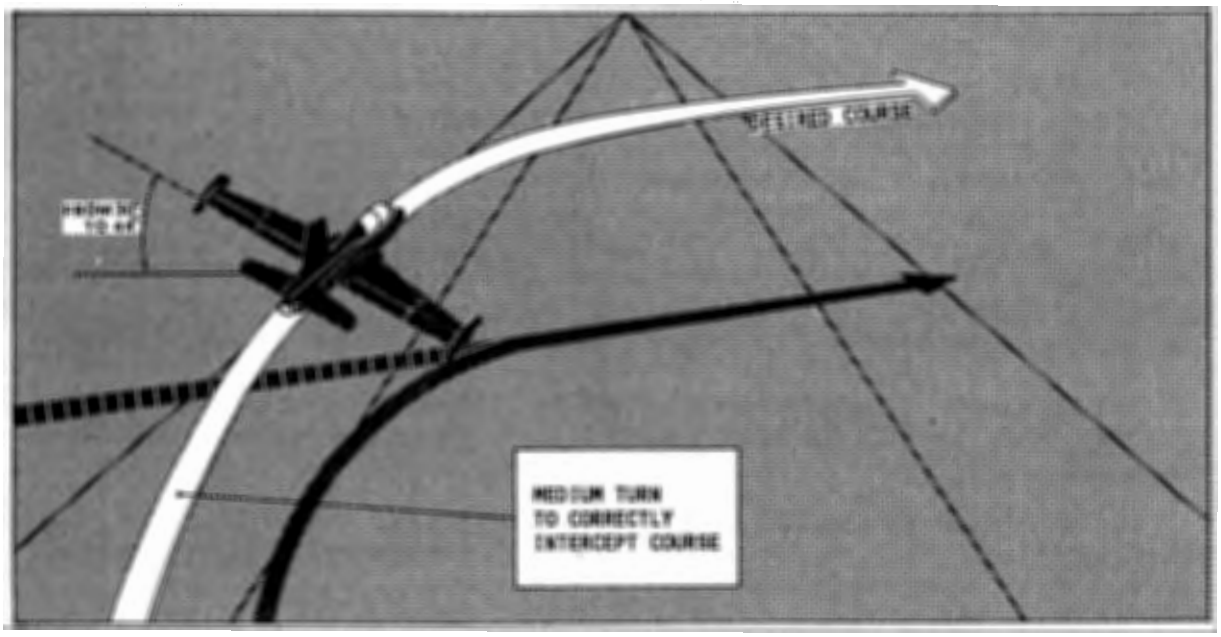


Figure 6-4. Medium Turn

When passing through 30° of bank, increase power (2% RPM more) to maintain the IAS.
Correct any altitude gains or losses by increasing or decreasing the back stick pressure and maintaining a constant angle of bank.
Check the aircraft attitude on the horizon line and the altimeter.
The rollout from a steep turn must be started with a lead in degrees equal to 20% of bank while reducing power.

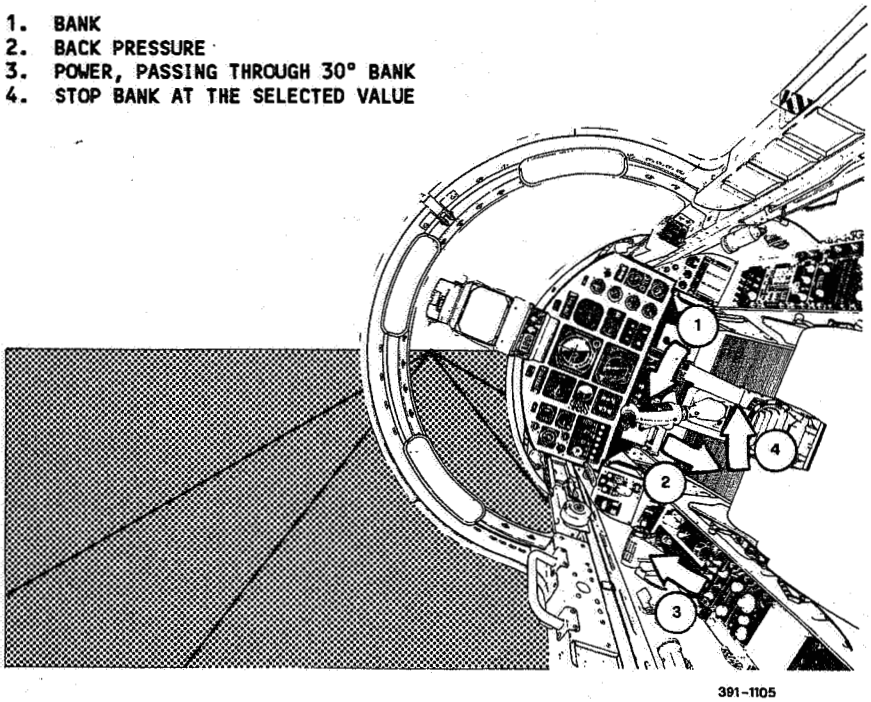


Figure 6-5. Steep Turn

d. Very Steep Turns

The very steep turns at constant altitude are coordinated aerobatics figures proper, which are only practised to familiarize the pilot with abrupt changes in heading and to teach him to maintain a precise control over airspeed, altitude and final direction.
Technique: very steep turns begin in the same way as steep turns: when passing through 30° of bank, increase the RPM by 2% to 3% and start applying back pressure on the control stick until the selected bank (beyond 60%) is attained.
Closely check the horizon line and correct any altitude errors as follows:

(1) Nose-low - decrease bank while maintaining the back stick pressure until the original altitude (altimeter) is attained; then resume the selected bank.

(2) Nose-high - Slightly and temporarily decrease the back stick pressure; return to the original altitude, reapply sufficient pressure on the stick to maintain altitude.
Do not change the bank.

NOTE

The angle of attack of the wings in a turn must increase to compensate for the "apparent" aircraft mass (mass x n x g) where n = load factor is 1,41 for 45° turns; 1 for 60° turns, 3 for 72° banked turns.

Increasing the angle of attack also increases the aerodynamic drag and causes a decrease in airspeed.
To maintain speed constant, it is necessary to increase the engine thrust (approx. 2% RPM more for 45° turns; 3% to 4% more for 60° bank turns, 8% to 10% more for turns banked beyond 70°).
During the rollout from a very steep turn, the lead on the selected heading and reference point both to level wings and reduce power, must be greater than in medium and steep.

4. AIRSPEED CHANGES

The purpose of these maneuvers is to familiarize the pilot with the attitude changes and the response of the controls to IAS changes (at constant altitude).
The maneuvers are divided into:

- Small changes of IAS : to 30 knots
- Great changes of IAS : 30 knots or more

a. Small Increases or Decreases in IAS

At constant altitude these changes require a plus or minus 1% change in RPM for every 10 knots of IAS change.
Temporarily add or remove 5% RPM to or from this value.
Balance (trim) as the airspeed increases or decreases.
With a lead of 2 to 3 knots on the desired IAS, remove or add the temporary 5% RPM and retrim the aircraft.

b. Extreme Increases in IAS

These changes require a calculation of the engine RPM to be used for the new required IAS (1% more every 10 knots of change); increase RPM to

100%. With a lead of 5 knots on the required IAS, retard the throttle to the calculated value, trim the aircraft longitudinally.

c. Extreme Decreases in IAS

These changes require a calculation of the new engine RPM to be used for the new required IAS (1% less every 10 knots of change); retard the throttle to this value, extend the speedbrake fully out, do not trim the aircraft; with a lead of 5 knots on the required IAS, retract the speedbrake, trim the aircraft at the required airspeed.

5. CLIMB OR DESCENT AT CONSTANT IAS, CONSTANT VERTICAL SPEED

The purpose of these maneuvers is to familiarize the pilot with the power changes necessary to set selected vertical speeds at constant IAS.
These maneuvers require very little trimming.
Remember that the aircraft has a natural tendency to go into a nose-high attitude when you increase power, into a nose-low attitude when you decrease power.
Technique: Tentatively add or remove 2% RPM every 250 ft/min with respect to the level flight power setting.
In long descents the engine will give an increased thrust (in denser air) for the same RPM.
Thus, as the altitude decreases, basically decrease the engine RPM by 5% when vertical speed is 0.5; 10% when vertical speed is 1; 15% when vertical speed is 1,5 (thousands of ft/ min) (fig. 6-6).

6. STALLS

a. Stall Conditions

The stall is the flight condition where the total aircraft lift (aerodynamic force) is incapable of balancing the mass forces (weight, load factor) perpendicular to the velocity vector (fig. 6-7).
According to this definition it is evident that stall can occur at any airspeed since it is dependent on the mass and the load factor which, under different flying conditions, can range from zero to the maximum value accepted by the structure (let us for the moment forget about the negative load factors and the negative lift).

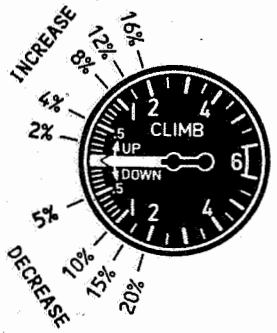


Figure 6-6. Power Variations in Climb and Dive at Constant IAS

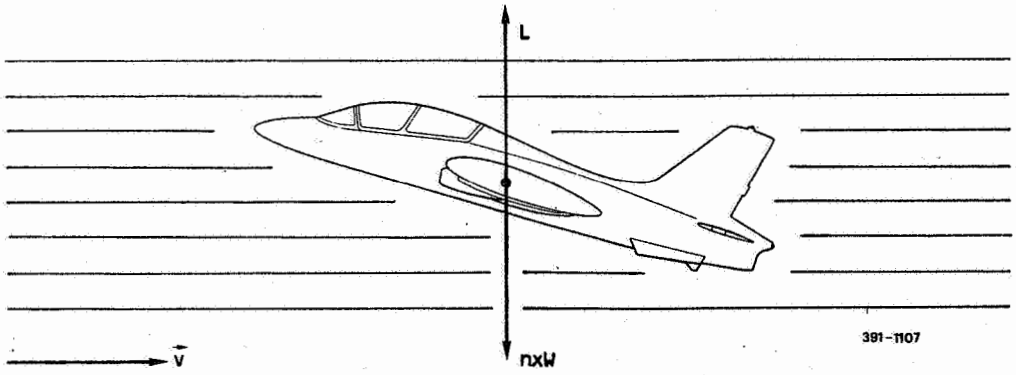


Figure 6-7. Equilibrium of Lift = nxW

During any maneuver prior to stall we shall have the following:

$L = (n \times g) \times M$ Where n x g is the acceleration normal to L, viz. the value on the accelerometer, and M is the aircraft mass but M x g (mass x gravity) is equal to W, thence L = n x W

during a maneuver with n < 1, the lift will therefore be always lower than the mass and stall speed will thus be lower than level flight speed.
During the phase preceding a hammer-head stall, the aircraft is almost vertical with a load factor close to zero and does not stall even at 25 to 30 kt of IAS (0,1 g), then it stalls abruptly. We shall examine the reasons later on.
The stall speed is proportional to n x W in a 4 g maneuver (n = 4), the Vs is Vs1 x $\sqrt{4}$ = 2 Vs1 viz. twice the stall speed in level flight (Vs).
For the MB-339A in clean configuration and with half fuel on board (3900 kg), Vs1 is 100 knots and stall speed at 4 g is 200 knots.
It is unimportant if the 4 g are applied in a turn or during a looping.

b. Aircraft Behaviour During a Stall

When the angle of attack exceeds the critical value (max. lift-to-drag ratio), the airflow on the wing (over the top of the wing, where pressures are lower), becomes more and more turbulent and tends to separate from the wing surface.
This phenomenon starts at the trailing edge and spreads toward the leading edge.
As a consequence, the lift centre moves forward and lift decreases with the increase of the angle of attack, while the aerodynamic drag increases considerably.
Since lift becomes insufficient, the aircraft sinks and the relative velocity vector takes up a greater angle of attack which makes the reduction in lift worse and leads to a stall.
The angle of attack corresponding to such a flying condition does not depend on mass, load factor or airspeed (at not too high Mach numbers) but only on the aerodynamic shape of the aircraft: it is a fixed datum for each type of aircraft and it governs the mass load factor and stall speed elements, connected by formula $Vs = \sqrt{nW}$.
The critical angle of attack or angle of stall obviously changes with the flap aerodynamic configuration.
The extension of the landing gear and/or the speedbrake does not conversely involve any change in the critical angle of attack.
The MB-339 aircraft is fitted with an instrument which indicates when the angle of stall is approached and attained.
This is the angle of attack indicator better known as AOA indicator

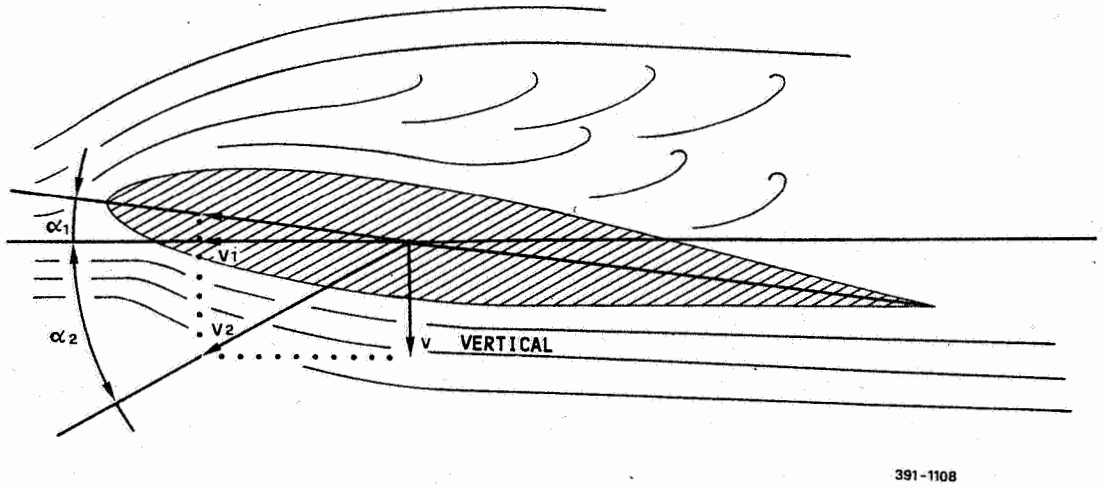


Figure 6-8. Sinking and Stall

(Angle of Attack Indicator) which provides to the pilot a very precise indication of the angle of attack α not in degrees but in conventional UNITS from ZERO to ONE.
See FM, Section I.
The subject will be dealt with later on in Chapter X, Section A of this manual.
The aircraft shows a natural tendency to recover from stall and stalls occur with no wing drop.
When the aircraft suffers a reduction in lift and sinks, the wing increases its aerodynamic angle of attack from α1 to α2 thus reducing lift further (fig. 6-8).
When the aircraft sinks, the negative incidence γ1 of the tailplanes, turns to positive incidence γ2 i.e. from a negative lift (heavy tail = nose-high) to a positive lift (light tail = nose-down), which decreases α and consequently makes the aircraft recover spontaneously from stall (fig. 6-9).
The tendency to stall without wing drop is due to different factors but especially to the wing tip washout.
The wing tip has in fact an incidence angle to the fuselage of one degree less than the center section.
It ensues that when the wing center section stalls, there is still sufficient lift on the two tips; the wing which drops faster (below the criti-

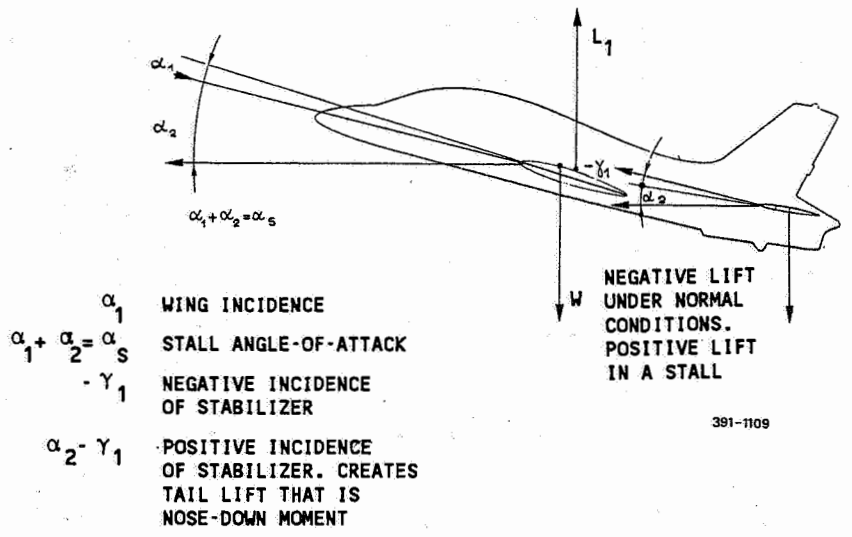


Figure 6-9. Spontaneous Recovery from Stall

cal angle of attack), still develops a higher lift than the wing which drops more slowly, and the aircraft is returned to a level off condition.
With the aircraft completely stalled viz. maintained in a condition of stall or of full aft stick stall (see following paras) the spontaneous tendency of the wings to level off may sometimes be absent and a wing may drop abruptly causing a yaw on the side of the dropping wing.
Altitude is lost during stall, sometimes considerably.
The types of stall that may be experienced in flight are many.
For those which are likely to occur most commonly, the recognition and recovery techniques will be treated in this manual.
It is important for the pilot to recognize the flight conditions that are conducive to stalls and know:

- The corrective actions to apply to prevent stall or
- The correct procedure to recover

c. Stall in Cruise Configuration (Clean Stall)

Carefully read the FM, Section V.
Stall speed (3900 kg mass) 100 KIAS.
This stall and recovery maneuver is carried out intentionally for training purposes in order to familiarize the pilot with the stall characteristics in level flight.
Technique (fig. 6-11): at 15 000 ft altitude, in the assigned area and with 250 KIAS, 84% RPM, carry out the pre-acrobatic checks, take a reference point suitable for direction, control decrease RPM to 60%, extend the speedbrake and perform a safety turn with 45° bank, recover from the turn after 180° ± 45° to clear the surrounding area.

NOTE

The IDLE position of the throttle lever corresponds to values higher than 60% RPM at altitudes above 14 000 ft. See the chart in figure 6-10.

The heading reference must be far away and/or high on the horizon since the aircraft in the stall approach phase will have a marked nose-high attitude (approx. 12°) with 0.82 AOA.
During the safety turn, speed will decrease, maintain altitude.
At the end of the turn readjust RPM to 60% and retract the speedbrake at 115 KIAS.
Back pressure on the stick to maintain attitude will now be stronger. Do not use the trim, keep the wings level and maintain altitude.
At this point, the horizon will tend to disappear under the nose, because of the marked nose-high attitude.
At 106 knots, you will recognize the first buffet warning of an impending stall (0.82 AOA).
Continue to increase back pressure until the aircraft will buffet decidedly at 100 knots and will sink concurrently lowering the nose (0.90 AOA).
The loss of altitude, may in some circumstances, be accompanied by a yaw (to be corrected by the rudder) and a wing drop.
In the MB-339A aircraft, the aileron remains effective also during the stall. This does not occur in other aircraft and the practise of correcting the yaw and wing drop by use of the rudder only, returning the rudder to neutral when the wings are at level, is therefore recommended. One second after the aircraft has entered stall, smoothly move the stick forward, until the nose is 10° to 15° below the horizon; the situation will be as shown in figure 6-12.
The horizon tangent line moves from down to up the windshield frame.
When the nose is below the horizon, advance the throttle lever to 100%

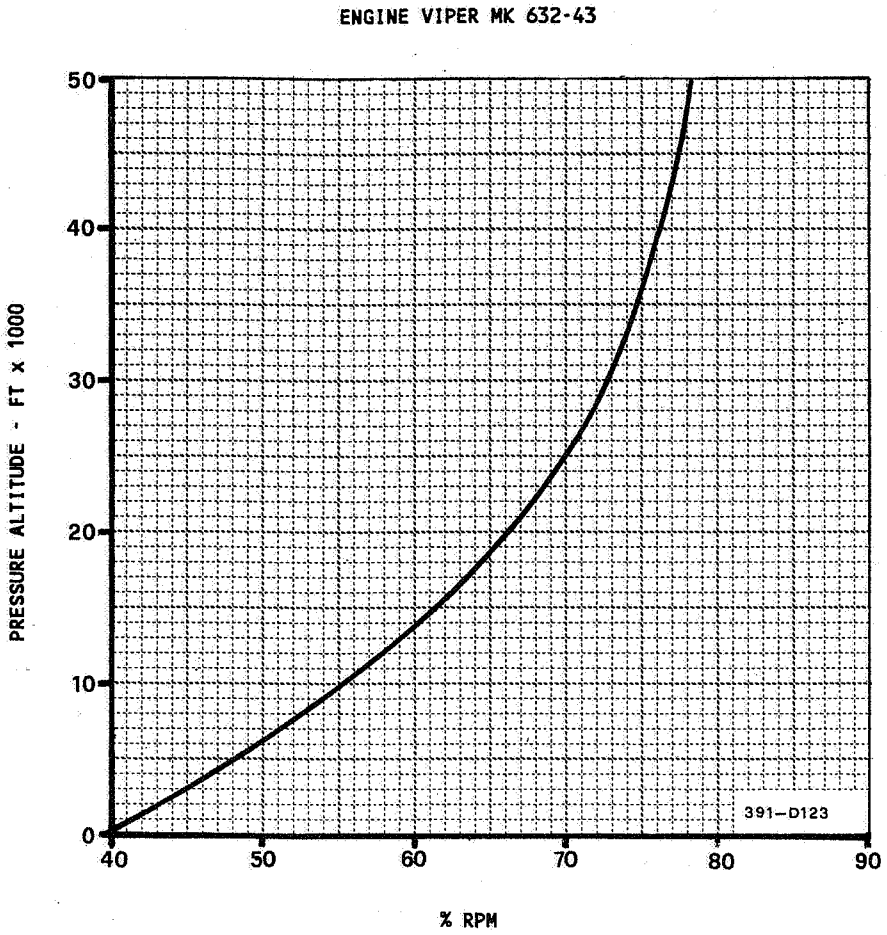


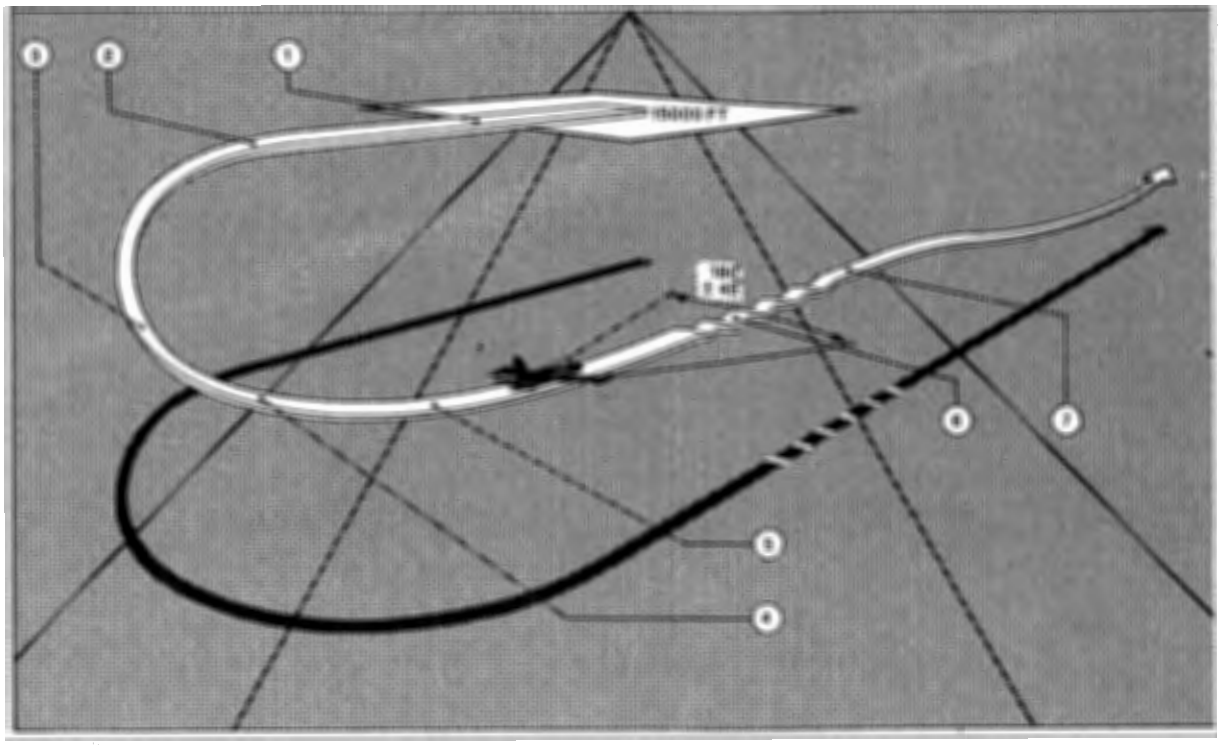
Figure 6-10. Engine Idle rpm vs altitude

RPM. When the aircraft is out of the stalled conditions, return it smoothly to level flight attitude.
Leave the power at 100% RPM.

WARNING

During recovery avoid abrupt movements of the throttle lever to prevent possible compressor stalls, or of the control stick, since the 15 degree nose-down attitude must be attained with no "push/pull" action which might lead to a secondary stall.
A nose low, but not too low, attitude eliminates the hazard of compressor stalls with a minimum loss of altitude.
With a correct recovery action, the altitude loss should be approx. 300 ft.

After recovery, to return the aircraft to cruise speed, apply the strong speed increase procedure (see para 4c.) while levelling the aircraft smoothly to avoid a secondary stall.
Climbing back to the original altitude will be started only when the selected airspeed has been attained.
Once the altitude has been attained, stabilize the attitude and reduce power to the cruise RPM (84%) when speed is 4 to 5 knots less than the selected 250 KIAS.
The intentional stall maneuver can only now be considered complete.



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1. 250 KIAS - 15000 FT
   PRE-ACROBATIC CHECKS
   TRIM
   PARALLEL TO REFERENCE
2. 65% RPM
   SPEEDBRAKE OUT
   TURN 180° ± 45°
3. 45° BANKED TURN
4. THROTTLE BACK TO 65% RPM
5. INCREASE BACK STICK PRESSURE
   HOLD ALTITUDE
   SPEEDBRAKE IN
6. STALL AT 100 KIAS (AOA → .90)
7. RECOVERY
   - STICK FORWARD
   - 100% RPM
   - LEVEL-OFF SMOOTHLY

Figure 6-11. Clean Stall

d. Full Aft Stick Stall

Practising full aft stick stalls in solo flight is prohibited.
This maneuver is accomplished intentionally for training purposes and can rarely occur in normal flying since it implies a gross inability to recognize stall.
The training is however designed to:
- develop the required feel and skill to maintain wings level by the rudder for a comparatively long time in flight in a full aft stick stall condition.

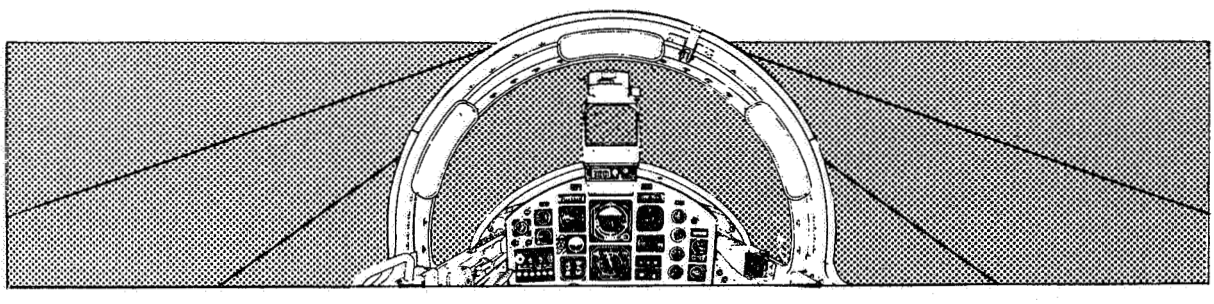

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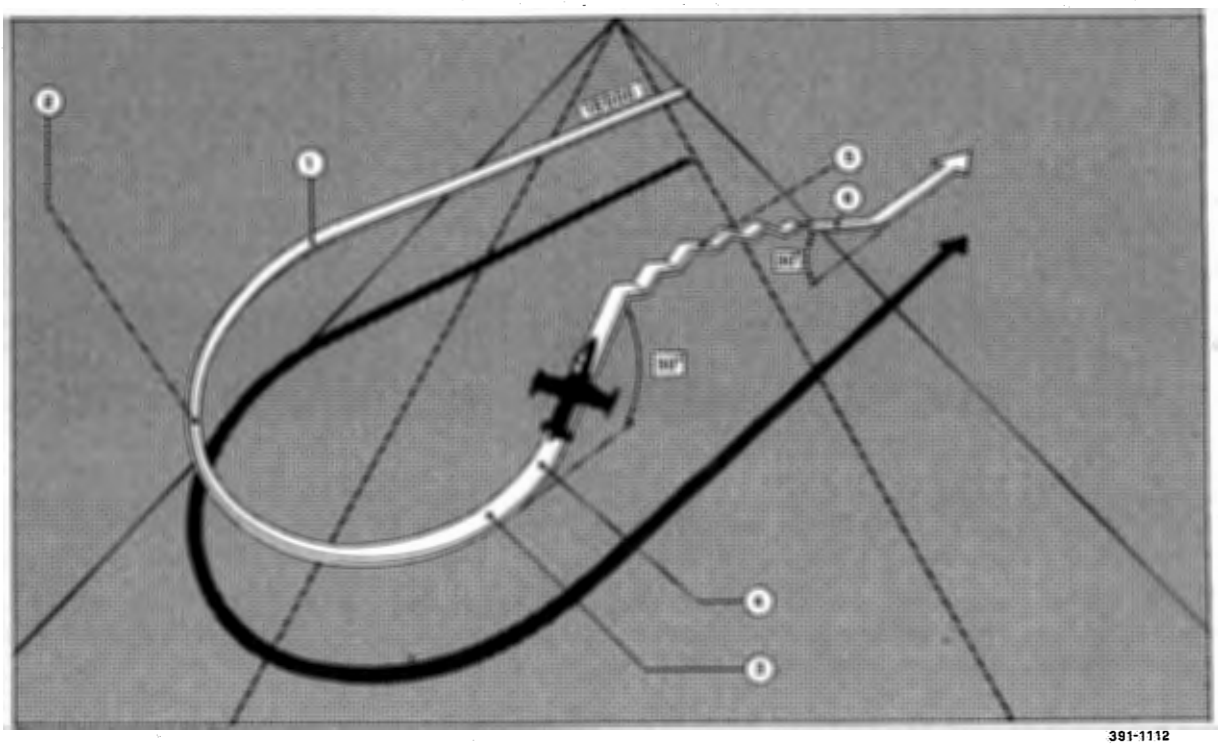
Figure 6-12. Attitude With Nose 15° Below Horizon



1-2. 45% BANK
65% RPM - SPEEDBRAKE OUT
3. AT 120 KIAS: TRIM
4. RAISE NOSE TO 30° AND APPLY 86% RPM WINGS LEVEL AT 100 KIAS: STALL
5. PULL STICK FULLY AFT
6. 100% RPM
SPEEDBRAKE IN
STICK FORWARD
LEVEL-OFF SMOOTHLY

Figure 6-13. Full Aft Stick Stall

- demonstrate that the aircraft recovers spontaneously even from a stall which is made worse by an incorrect initial corrective action.

- demonstrate that the MB-339A has no tendency to pitch-up in a stall.

Technique (fig. 6-13): The first phase of the maneuver is the same as the one preceding the "clean stall" until the safety turn is completed. When the turn is completed, start climbing with the speedbrake out to a flightpath angle of 30° to 35°.
At 120 knots IAS adjust the throttles to 86% RPM and trim.
Hold a 30° to 35° nose-high attitude: maintain heading with the outside references and the ADI.
Back stick pressure will become increasingly marked to maintain normal flight attitude.
Do not trim.
At 106 knots and 0.82 AOA a stall warning buffet will start.
At 100 knots and 0.90 AOA the aircraft will stall. Smoothly but briskly move the control stick full aft against the stop to oppose the sinking and correct the wing drop tendency with opposite rudder. Do not apply lateral stick pressure.
Allowing the stall to develop, the aircraft will lower its nose slowly still sinking.
When the nose is below the horizon the aircraft if left alone, would recover from stall with a considerable loss of altitude.

Help stall recovery by smoothly moving the stick forward and increasing power (smoothly) up to 100%.
Stop the nose-down attitude, 30° below the horizon (fig. 6-14) and recover as instructed for the "clean stall".

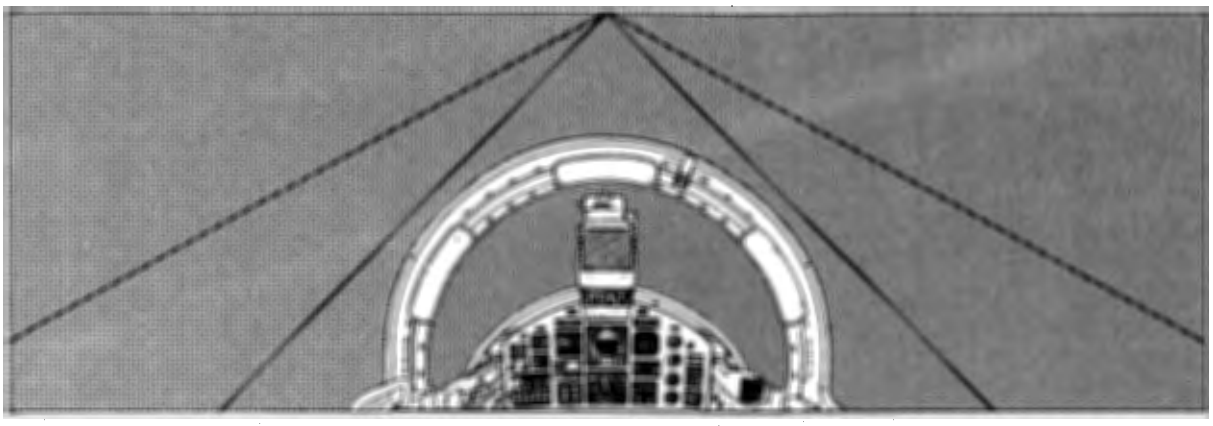


Figure 6-14. Nose 30° Below Horizon

If during a full aft stick stall a wing should drop beyond 45°, immediately initiate the recovery by moving the control stick forward with 100% engine RPM, while controlling the bank with the rudder.

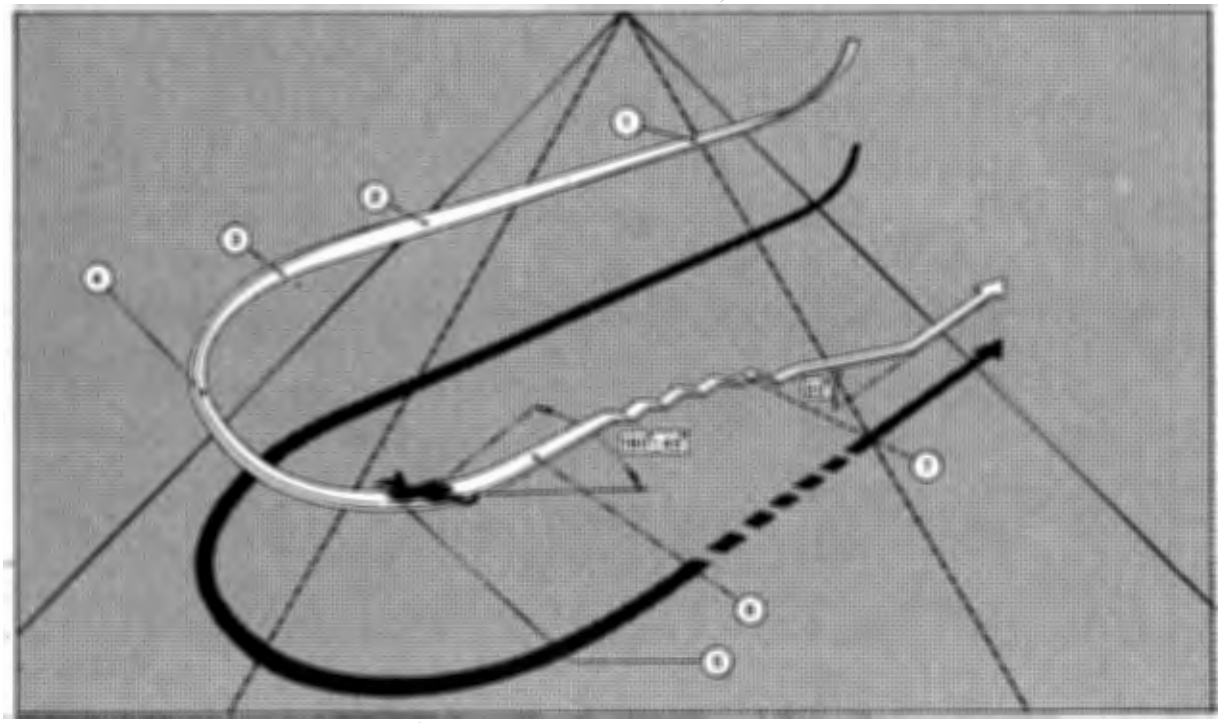
e. Stall in Landing Configuration (Dirty Stall)

Carefully read the "STALL" paragraph in section VI of the FM.
Stall speed (3900 kg mass) 89 KIAS.
This stall and recovery maneuver (fig. 6-15) is performed intentionally for training purposes to develop the pilot's ability to recognize and recovery from a stall during level flight in landing configuration.
The entry procedure is the same as for a stall in cruise configuration viz.: at 15 000 ft altitude, in the assigned area, with 84% RPM, 250 KIAS, carry out the pre-acrobatics checks, take up the selected reference, decrease RPM to 60%, extend the speedbrake and perform a 180 ± 45° safety turn at constant altitude with 45° bank.

NOTE

The IDLE position of the throttle lever corresponds to values higher than 60% RPM at altitudes above 14 000 ft. See charts in figure 6-10.

Once the turn in the direction of the reference point is completed, allow airspeed to decrease to 175 KIAS and extend the landing gear.
The longitudinal trim can be used only until the landing gear is extended.
Check that the RPM is not less than 60%. Check that the landing gear is down and, at 140 KIAS, extend the flaps to the landing position monitoring their extension on the instrument.
Bear in mind that flap extension creates a nose-high moment which must be opposed with the control stick only (no trim).
Airspeed will decrease very rapidly and a back stick pressure will almost immediately be applied to maintain altitude.
Maintain the direction with the visual references and check that the wings are level.
At approx. 91 KIAS airspeed, with 0.85 AOA and 11° nose-high attitude above the horizon, initial buffet occurs, soon followed by the stall at 89 KIAS and 0.90 AOA.
For the recovery, lower the aircraft nose 20° to 25°. When the nose lowers below the horizon, increase power (smoothly) to 100% RPM.
Oppose a possible wing drop, with the rudder.
Return to level flight slowly and smoothly in order to avoid a secondary stall.



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1. 15000 FT AND 250 KIAS
   PRE-ACROBATIC CHECKS-TRIM
   PARALLEL TO REFERENCE
2. 60% RPM - SPEEDBRAKE OUT
3. 45% BANK
   180° ± 45° TURN
4. THROTTLE CHECK 60% RPM
5. 175 KIAS
   . LANDING GEAR DOWN
   . RETRACT SPEEDBRAKE
   . CHECKS BEFORE LANDING
   . INCREASE BACK STICK PRESSURE
6. AT 140 KIAS - FLAPS FULLY DOWN
   . WINGS LEVEL - HOLD ALTITUDE
   . AT 95 KIAS - PRE-STALL
7. AT 89 KIAS - STALL
   RECOVERY: CONTROL STICK FORWARD
   SPEEDBRAKE IN - 100% RPM
   LEVEL-OFF SMOOTHLY
   WINGS LEVEL - LANDING GEAR UP AT
   120 KIAS RAISE FLAPS CABIN CHECKS

Figure 6-15. Dirty Stall

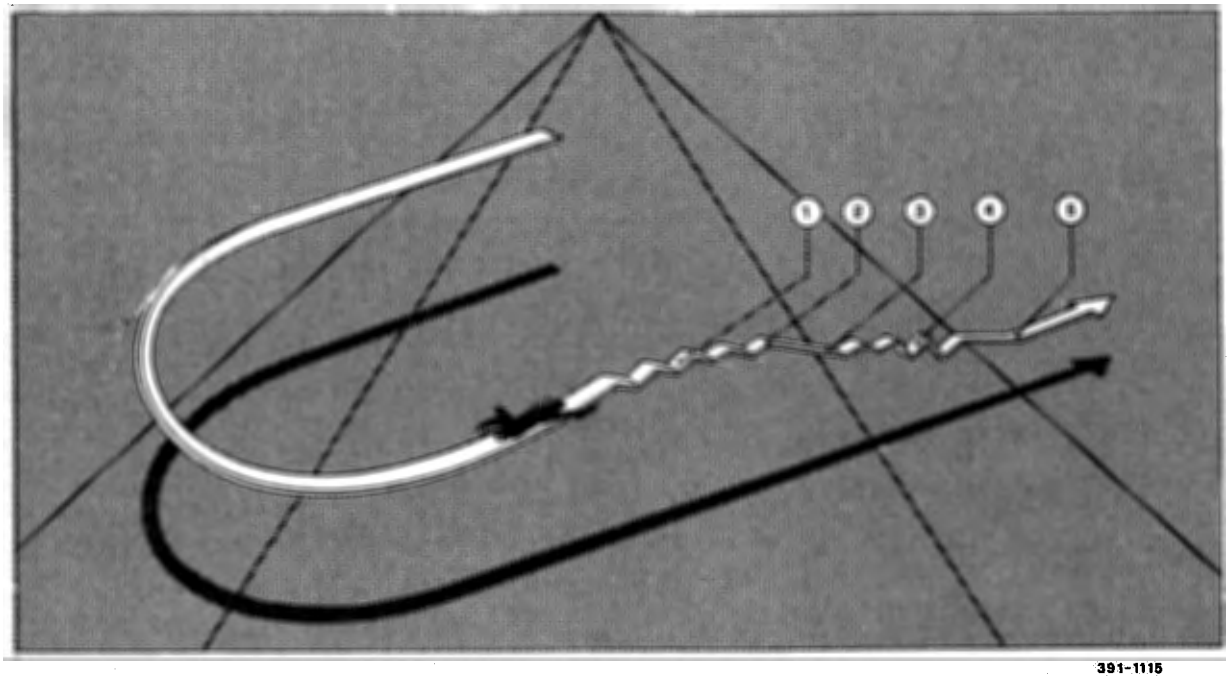
When the aircraft is levelled, retract the landing gear. At 120 KIAS retract the flaps, oppose the nose drop by slightly moving the stick back first to T/O and then to UP.
Carry out the go-around checks and once the 250 KIAS airspeed is attained, return to the original altitude and decrease RPM to 84%.

f. Secondary Stall

If an abrupt or excessive back stick pressure is applied to return the aircraft to level flight after initiating stall recovery, the critical AOA may be exceeded again and a new stall entered; this special type of stall is referred to as "secondary stall" (fig. 6-16).
To the effects of training the parameters, configuration and reference points are the same as for the normal stall.

(1) When performing a normal stall, initiate recover by briskly bringing the control stick back to return the aircraft to level flight: under these conditions the aircraft will stall again; buffet, nose drop and a possible wing drop will be experienced again; all these phenomena will be more evident than in a normal stall.

(2) For recovery it is sufficient to release the pressure on the stick and to proceed as in a normal stall recovery.



391-1115

1. NORMAL STALL
2. START RECOVERY FROM NORMAL STALL
3. BRISKLY MOVE STICK AFT
4. SECONDARY STALL
5. RECOVERY: RELAX BACK STICK PRESSURE

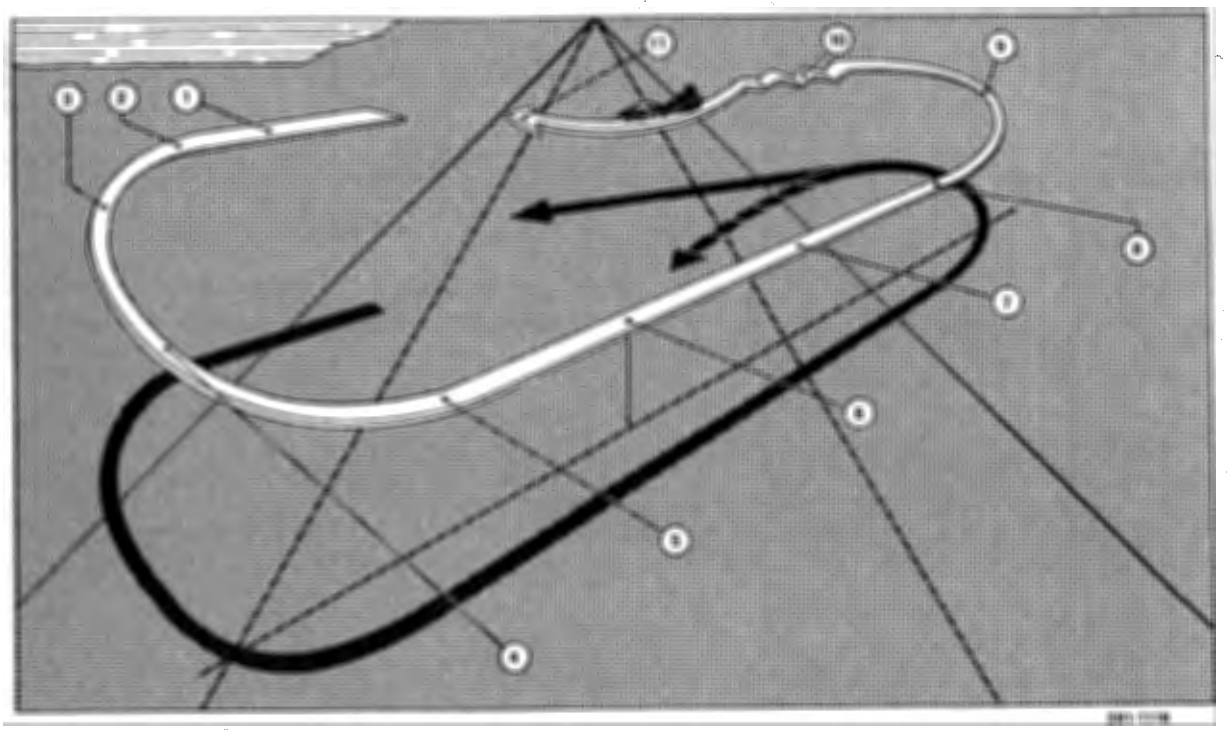
Figure 6-16. Secondary Stall

g. Final Turn Stall

Stall speed approx. 100 KIAS (3900 kg mass).
This stall and the recovery maneuvers are performed intentionally for training purposes and to familiarize the pilot with the possible stalls due to an incorrectly entered final turn (fig. 6-17)
Technique: at 15 000 ft altitude, in the assigned area and with 250 KIAS, 84% RPM, carry out the pre-acrobatic checks and take an attitude parallel to a rectilinear ground reference.
Decrease RPM to 70%, extend the speedbrake and perform a 180° turn with 45° bank.
Level the wings, maintain the altitude, allow airspeed to decrease to 175 KIAS and extend the landing gear.
Trim, check that the landing gear is down, retract the speedbrake.
At 150 KIAS, select the flaps to T/O, monitoring the flap position indicator.
At 130 KIAS initiate to simulate a final turn with 0.45 AOA and reference to the selected alignment, in slight descent (approx. 700 to 1000 ft/min), 30° to 45° bank.
Progressively increase the back stick pressure until buffet occurs (0.82 AOA).
Recover from the stall by relaxing the back pressure on the stick and concurrently increasing power to 100% RPM.
Level the wing and smoothly stop the altitude loss, then retract the landing gear.
At 125 KIAS retract the flaps, then carry out the "after go-around" checks.

h. Stall Under Load Factor (G Stall)

Stall speed depending upon the load factor.



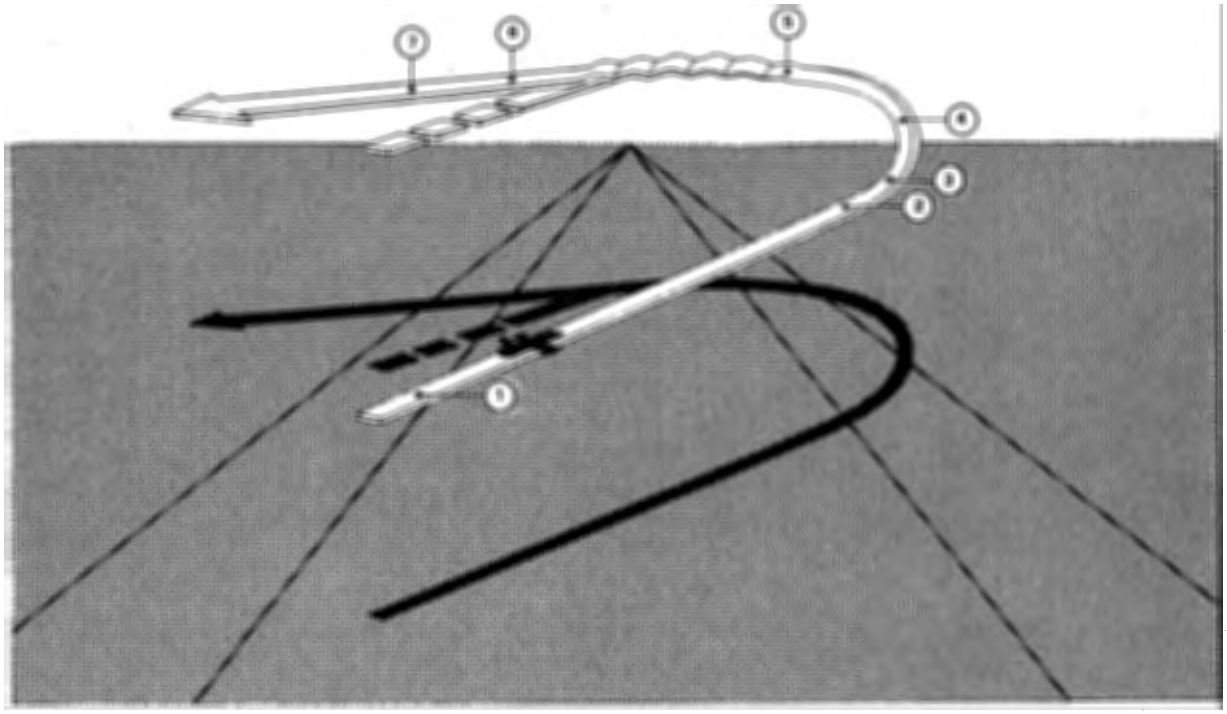
1. 250 KIAS - 84% RPM - 15000 FT
   PRE-ACROBATIC CHECKS
   TRIM
   REFERENCES
2. 70% RPM AND SPEEDBRAKE OUT
   45° BANK
3. 180° TURN
4. RESTORE 70% RPM
5. LEVEL FLIGHT AT 15000 FT
   APPLY BACK STICK PRESSURE
6. AT 175 KIAS LANDING GEAR DOWN AND SPEEDBRAKE UP
7. AT 150 KIAS T/O FLAPS
8. AT 130 KIAS MAKE A DESCENDING TURN
9. INCREASE BACK STICK PRESSURE
10. STALL: BUFFET AND AOA .82
11. RECOVERY: RELAX BACK PRESSURE ON STICK AND APPLY 100% RPM

Figure 6-17. Stall in a Final Turn

As a guideline: 140 KIAS at 2g; 173 KIAS at 3g and 200 KIAS at 4g. This stall maneuver is performed intentionally to make the pilot proficient in recognizing and recovering from an incipient stall caused by an excessive load factor application.
A "break up" stall condition is simulated.
Technique: at 15 000 ft altitude, in the assigned area and with 250 KIAS, 84% RPM, carry out the pre-acrobatic checks, and take an attitude parallel to a rectilinear ground reference; then, simulate a "break", i.e. decrease RPM to 60%, extend the speedbrake and, at the same time, start turning in level flight with a bank of 50° to 60°. Decidedly increase back stick pressure until the buffet indication of incipient stall (AOA 0.82) is clearly felt. Recovery is obtained by simply relaxing back pressure on the stick.
Then, bring the wings level, retract the speedbrake while increasing briskly but not abruptly the power to 100%, and return to cruise conditions.

7. SLOW FLIGHT

The purpose of slow flight is to familiarize the pilot with the behaviour of the aircraft and its response to control pressures in level flight and at an airspeed close to stall speed.



391-1117

1. 250 KIAS - 15000 FT - 84% RPM
   PRE-ACROBATIC CHECKS
   TRIM
   CHECK VISUAL REFERENCE
2. 60% RPM
   SPEEDBRAKE OUT
   START FLARE
3. STABILIZE TURN
4. 60° BANK
5. PULL STICK BRISKLY AFT TO STALL
6. RELAX BACK PRESSURE ON STICK
7. 100% RPM
   SPEEDBRAKE IN
   WINGS LEVEL

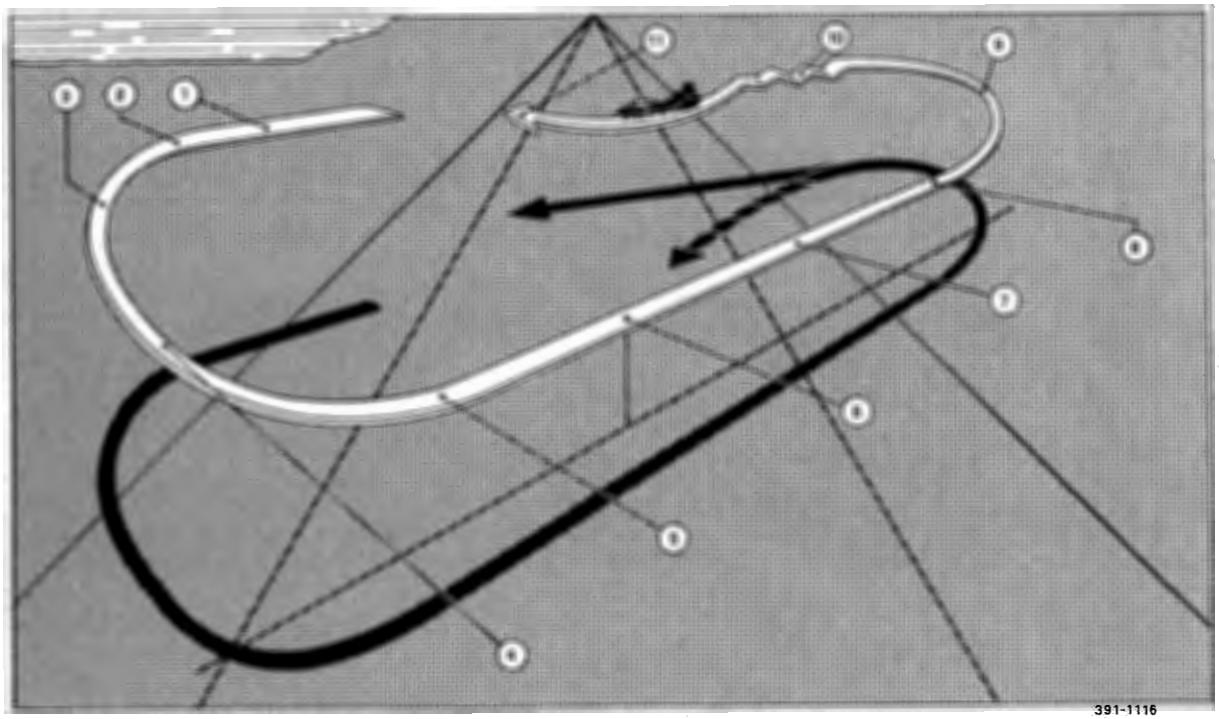
Figure 6-18. G-Stall

a. Slow flight in cruise configuration (fig. 6-19)

After carrying out the pre-acrobatic checks at FL 150, decrease power to IDLE or 60% RPM and extend the speedbrake.
Allow airspeed to decrease down to 120 KIAS (AOA 0.65), trimming as required to maintain altitude. At 120 KIAS retract the speedbrake and start increasing power up to 76% RPM to stabilize the airspeed at 115 IAS (AOA 0.70).
Perform shallow turns with 15° bank. Apply the controls smoothly.
Recover by increasing power to 100% RPM until cruise speed is reached. Trim.

b. Slow flight in landing configuration (fig. 6-20)

After carrying out the pre-acrobatic checks at FL 150, decrease power to IDLE (60% RPM) and extend the speedbrake. At 170 KIAS, lower the landing gear, retract the speedbrake and check that the landing gear is down and locked.
At 140 KIAS extend the flaps, then trim and advance the throttle slowly (approx. 87% RPM) to stabilize at 105 KIAS (AOA approx. 0.60).
Perform shallow turns with a max. bank of 15°, applying the controls smoothly.
Recover by increasing power to 100% RPM, retracting the landing gear immediately and the flaps at 125 KIAS (first T/O, then UP). Perform the same checks as after a go-around (visually check that the landing gear and the flaps are up). Reduce power to attain cruise speed. Trim.



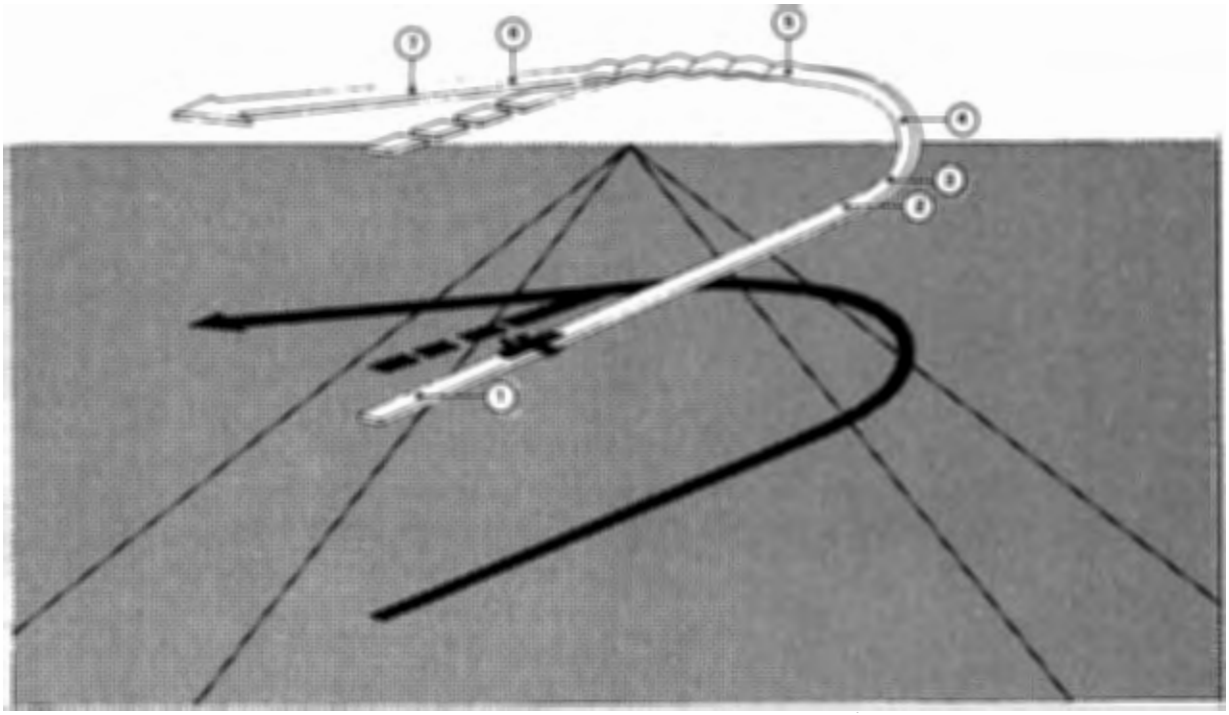
1. 250 KIAS - 84% RPM - 15000 FT
   PRE-ACROBATIC CHECKS
   TRIM
   REFERENCES
2. 70% RPM AND SPEEDBRAKE OUT
   45° BANK
3. 180° TURN
4. RESTORE 70% RPM
5. LEVEL FLIGHT AT 15000 FT
   APPLY BACK STICK PRESSURE
6. AT 175 KIAS LANDING GEAR DOWN AND SPEEDBRAKE UP
7. AT 150 KIAS T/O FLAPS
8. AT 130 KIAS MAKE A DESCENDING TURN
9. INCREASE BACK STICK PRESSURE
10. STALL: BUFFET AND AOA .82
11. RECOVERY: RELAX-BACK PRESSURE ON STICK AND APPLY 100% RPM

Figure 6-17. Stall in a Final Turn

As a guideline: 140 KIAS at 2g; 173 KIAS at 3g and 200 KIAS at 4g. This stall maneuver is performed intentionally to make the pilot proficient in recognizing and recovering from an incipient stall caused by an excessive load factor application.
A "break up" stall condition is simulated.
Technique: at 15 000 ft altitude, in the assigned area and with 250 KIAS, 84% RPM, carry out the pre-acrobatic checks, and take an attitude parallel to a rectilinear ground reference; then, simulate a "break", i.e. decrease RPM to 60%, extend the speedbrake and, at the same time, start turning in level flight with a bank of 50° to 60°. Decidedly increase back stick pressure until the buffet indication of incipient stall (AOA 0.82) is clearly felt. Recovery is obtained by simply relaxing back pressure on the stick.
Then, bring the wings level, retract the speedbrake while increasing briskly but not abruptly the power to 100%, and return to cruise conditions.

7. SLOW FLIGHT

The purpose of slow flight is to familiarize the pilot with the behaviour of the aircraft and its response to control pressures in level flight and at an airspeed close to stall speed.



391-1117

1. 250 KIAS - 15000 FT - 84% RPM
   PRE-ACROBATIC CHECKS
   TRIM
   CHECK VISUAL REFERENCE
2. 60% RPM
   SPEEDBRAKE OUT
   START FLARE
3. STABILIZE TURN
4. 60° BANK
5. PULL STICK BRISKLY AFT TO STALL
6. RELAX BACK PRESSURE ON STICK
7. 100% RPM
   SPEEDBRAKE IN
   WINGS LEVEL

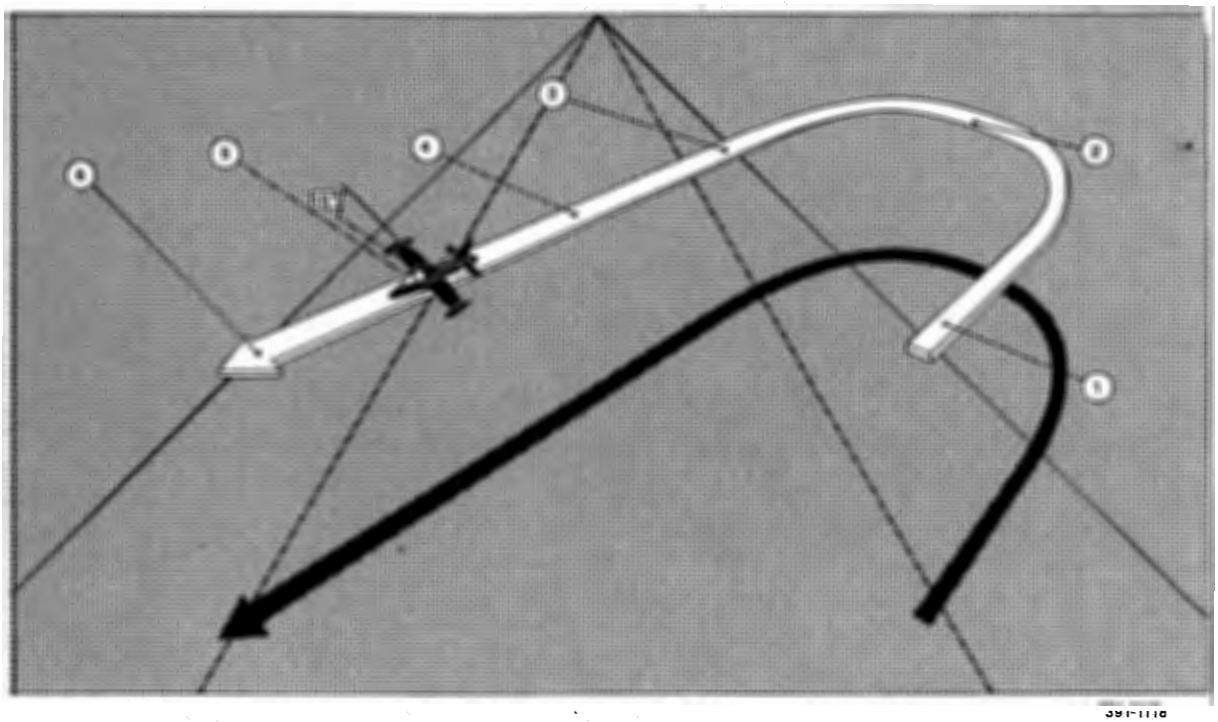
Figure 6-18. G-Stall

a. Slow flight in cruise configuration (fig. 6-19)

After carrying out the pre-acrobatic checks at FL 150, decrease power to IDLE or 60% RPM and extend the speedbrake.
Allow airspeed to decrease down to 120 KIAS (AOA 0.65), trimming as required to maintain altitude. At 120 KIAS retract the speedbrake and start increasing power up to 76% RPM to stabilize the airspeed at 115 IAS (AOA 0.70).
Perform shallow turns with 15° bank. Apply the controls smoothly.
Recover by increasing power to 100% RPM until cruise speed is reached. Trim.

b. Slow flight in landing configuration (fig. 6-20)

After carrying out the pre-acrobatic checks at FL 150, decrease power to IDLE (60% RPM) and extend the speedbrake. At 170 KIAS, lower the landing gear, retract the speedbrake and check that the landing gear is down and locked.
At 140 KIAS extend the flaps, then trim and advance the throttle slowly (approx. 87% RPM) to stabilize at 105 KIAS (AOA approx. 0.60).
Perform shallow turns with a max. bank of 15°, applying the controls smoothly.
Recover by increasing power to 100% RPM, retracting the landing gear immediately and the flaps at 125 KIAS (first T/O, then UP). Perform the same checks as after a go-around (visually check that the landing gear and the flaps are up). Reduce power to attain cruise speed. Trim.



1. LEVELLED-OFF AT 15000 FT
   PRE-ACROBATICS CHECKS
   60% RPM - SPEEDBRAKE OUT
2. IF REQUIRED, TURN TO HOLD THE AREA
3. AT 120 KIAS, SPEEDBRAKE IN - TRIM
4. AT APPROX. 76% RPM - 115 KIAS - WINGS LEVEL
5. 15° BANKED TURNS
6. RECOVERY: 100% RPM
   SPEEDBRAKE IN
   TRIM

Figure 6-19. Slow Flight in Cruise Configuration

8. COMPRESSIBILITY

See FM, Section VI.

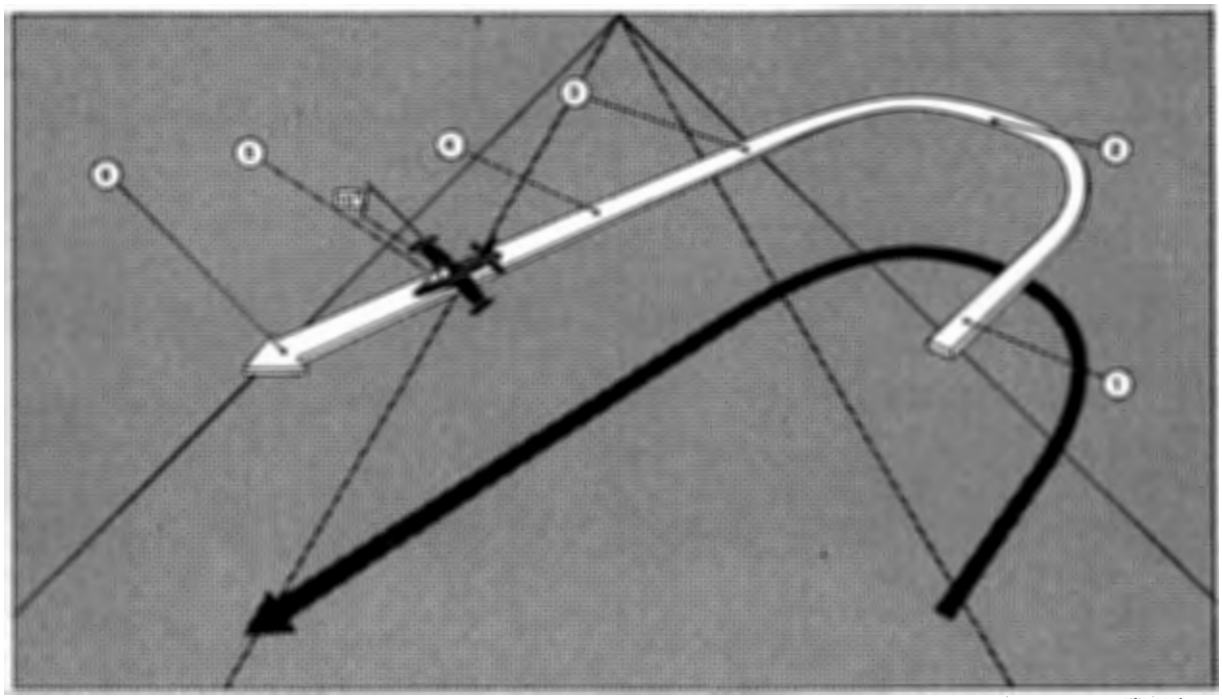
a. General

The intentional compressibility maneuver is used to demonstrate the aircraft behaviour at high Mach number and is carried out at high altitude (FL 350) so that at high true airspeeds (TAS) there correspond modest indicated airspeeds (IAS) and modest aerodynamic loads on the structure.
At 35 000 ft, the MB-339A limit Mach number of 0.82 is reached with an airspeed of 270 KIAS even if the TAS is 475 knots.

b. Technique

Level the aircraft at FL 350 and carry out the pre-acrobatic checks. Advance the throttle smoothly to maximum power (RPM will not exceed 98% RPM), bank the aircraft 45° allowing the nose to drop 45° below the horizon, then roll the wings level. Oppose the nose-up tendency due to the increase in speed.
The first easily controllable compressibility phenomena will be encountered at Mach 0.76. Heavy buffeting will result around Mach 0.80 with the possibility of a wing drop to be opposed.
The ailerons are servo-controlled; the lateral force on the stick will therefore be the same as in normal flight maneuvers.

Recovery is obtained by smoothly retarding the throttle to IDLE and pulling up softly.



1. PRE-ACROBATIC CHECKS - 60% RPM
   SPEEDBRAKE OUT
2. IF REQUIRED, TURN TO HOLD AREA
3. AT 170 KIAS
   LANDING GEAR DOWN
   CHECKS
4. AT 140 KIAS
   SPEEDBRAKE IN
   FLAPS DOWN,WINGS LEVEL
   POWER SETTING
   AS REQUIRED, IAS 105 Kt
5. 15° MAX BANK TURNS
6. RECOVERY: 100% RPM
   (SPEEDBRAKE IN) - LANDING GEAR
   DOWN 125 KIAS - FLAPS T/O, THEN
   UP VISUAL REFERENCE: CHECK

Figure 6-20. Slow Flight in Landing Configuration

See FM, Section VI.
Extend the speedbrake thus opposing the initial tendency of the aircraft to excessively raise the nose excessively.
Level the aircraft off as soon as possible, retract the speedbrake and set RPM as required for cruise flight.

PART TWO - CHAPTER VII

DESCEND FROM HIGH ALTITUDE - APPROACHES AND LANDINGS

TABLE OF CONTENTS

Title	Page
Descents and Low Altitude Level-Offs	7-1
Traffic Pattern	7-8
Landing	7-13

1. DESCENTS AND LOW ALTITUDE LEVEL-OFFS

Descents are the procedures required to reach lower altitudes.

a. General, Types of Descents

Descents can be classed as follows, according to the required descent technique:

(1) Gliding descent - or maximum range descent

(2) Moderate descent - or normal descent

(3) Rapid descent - or penetration descent

(4) Aided descent - or instrument penetration descent

(5) Slow aided descent - or instrument final approach

It is recommended that reference be made to the FM and the "Performance Data Manual".

NOTE

Prior to any descent, it is imperative that the checks prescribed in the checklist be accomplished, namely:

- "ENGINE ANTI/ICE" - as required
- Navigation and communication systems - ready
- "DEMIST" - ON
- Hydraulic pressures - within limits
- Fuel: check quantity
- "ADI" and "STBY Attitude Indicator" - cross check
- "HSI" - check
- Contact APP asking for instructions and QNH
- Altimeter - QNH and check

b. Gliding Descent, or Maximum Range Descent (fig. 7-1)

The aircraft glides when its only thrust is the mass component along the trajectory.
A gliding descent is effected with the engine throttle at IDLE and 150

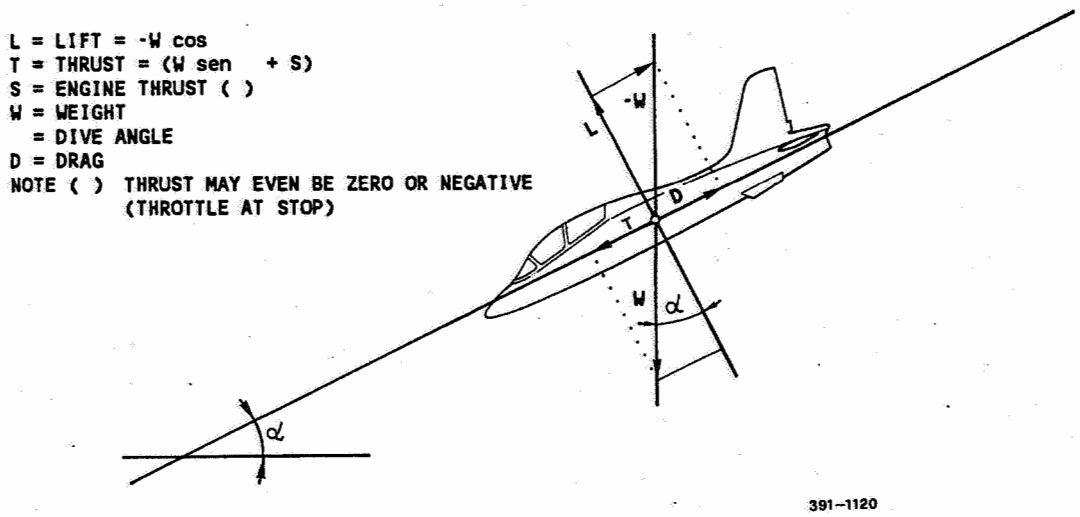


Figure 7-1. Glinding Descent

KIAS at all altitudes. In a gliding descent, the AOA will be 0.42 corresponding to a maximum range alpha (minimum possible alpha/maximum lift to drag ratio).
AOA 0.42 corresponds to a pointer position below the approach mark, almost at its lower edge.
Technique: slowly reduce RPM to IDLE while maintaining level flight path; when speed attains 150 KIAS, allow the nose to go down. Maintain 150 KIAS/0.42 AOA by trimming.

NOTE

JPT should not go down below 200°C. If required, suitably increase the RPM while maintaining the IAS constant.

c. Moderate or Normal Descent

It is flown as the gliding descent, but with the following parameters:

(1) Engine: IDLE

(2) Speedbrake: UP

(3) Mach 0.55 down to 30 000 ft, 200 KIAS from 30 000 ft to sea level.

For training purposes and at any rate starting from altitudes lower than FL 300, a moderate descent is flown at 250 KIAS, with the engine at IDLE or a power setting not lower than 60% RPM, speedbrake UP.
After the pre-descent checks, reduce RPM to 60% and concurrently lower the nose to attain and maintain 250 KIAS.
Trim to remove stick forces.
Steep and very steep turns can be made during a descent both as a training maneuver and to avoid flying in weather (fig. 7-2).

d. Rapid Descent or Penetration Descent (fig. 7-3)

It is the most frequently used descent under VFR conditions, to rapidly attain lower altitudes. The parameters to be maintained are:

- Engine at IDLE (at high altitude the IDLE position corresponds approx. to 65% RPM)

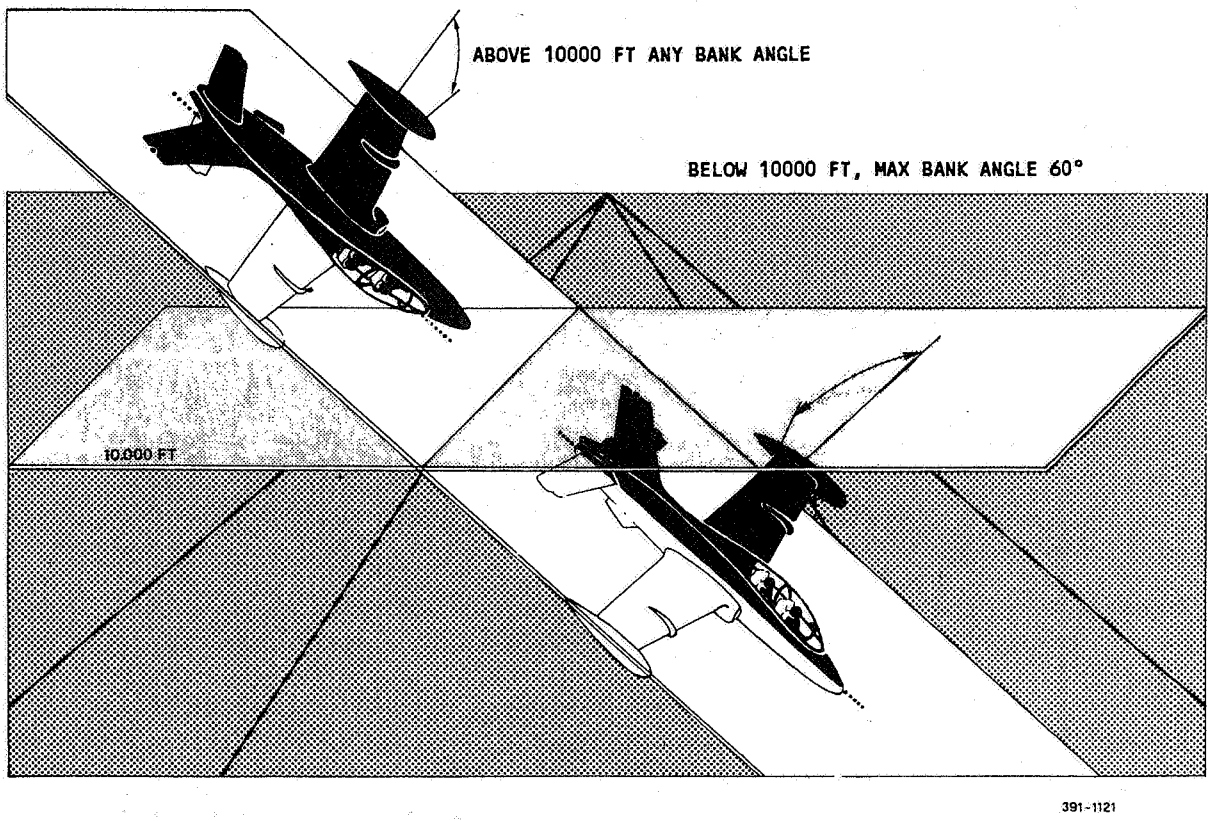


Figure 7-2. Descending Turns

- Speedbrake OUT
- Mach 0.60 down to 25 000 ft, then 250 KIAS from 25 000 ft to sea level

Three different procedures are identifiable as a function of the cruise IAS and descent IAS.

(1) Cruise IAS same as descent IAS. Reduce the power setting and concurrently lower the aircraft nose. At the first speed increase (approx. 5 knots), extend the speedbrake and counteract its nose up effect. Maintain the prescribed airspeed and trim the aircraft longitudinally.

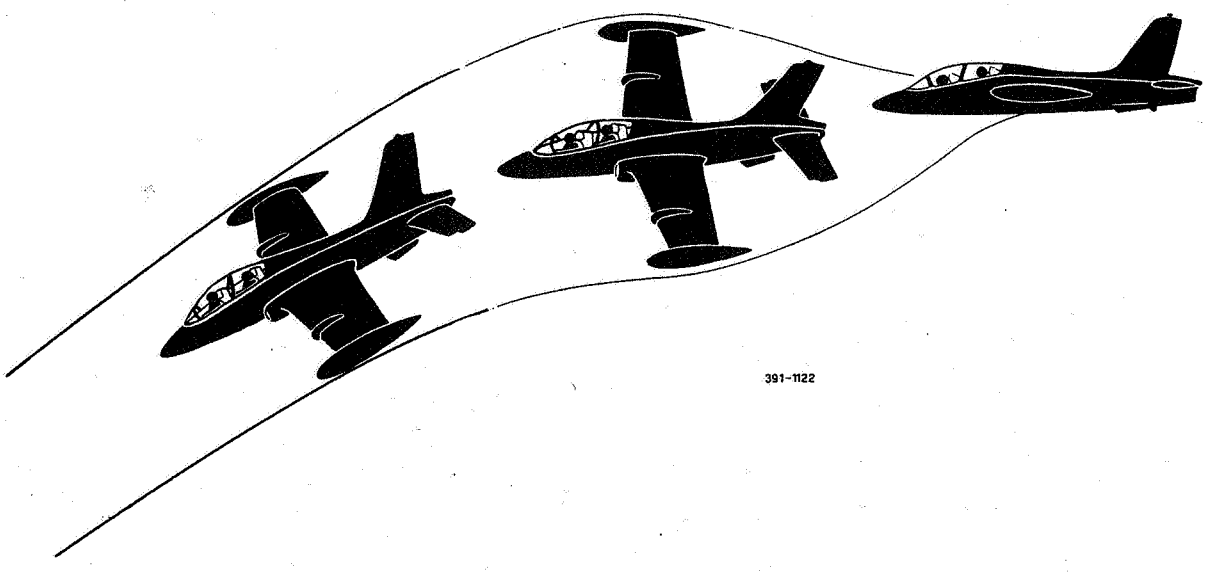


Figure 7-3. Start of Rapid Descend

(2) Cruise IAS lower than descent IAS. Lower the aircraft nose, banking it as required to avoid negative accelerations.
With a 5 kt lead on the descent IAS, reduce the engine speed to IDLE and extend the speedbrake.
At stabilized attitude and speed, suitably adjust the longitudinal trim.

(3) Cruise IAS higher than descent IAS. In the particular but unlikely case of a high cruise IAS, it will be necessary to lower the speedbrake and reduce RPM with the aircraft in level flight, then to lower the aircraft nose and attain the descent IAS.

NOTE

The selected IAS (Mach) is to be maintained constant throughout the descent, unless valid reasons (to avoid flying in weather or to clear traffic) may recommend its temporary change (fig. 7-4).

For training purposes, penetration is made at 250 KIAS.
Reduce power to 60% and concurrently lower the nose below the horizon line.
When the increase in speed exceeds 5 knots, extend the speedbrake and counteract its nose-up moment first with the stick and then with the trim. Attain and maintain 250 KIAS. Steep and very steep turns can be made, bearing in mind that with an increase in bank, the aircraft nose has a tendency to drop as the airspeed increases. Correct by using the control stick and the trim.

NOTE

- When descending from altitudes higher than 10 000 ft, turns can be made with whatever angle of bank.

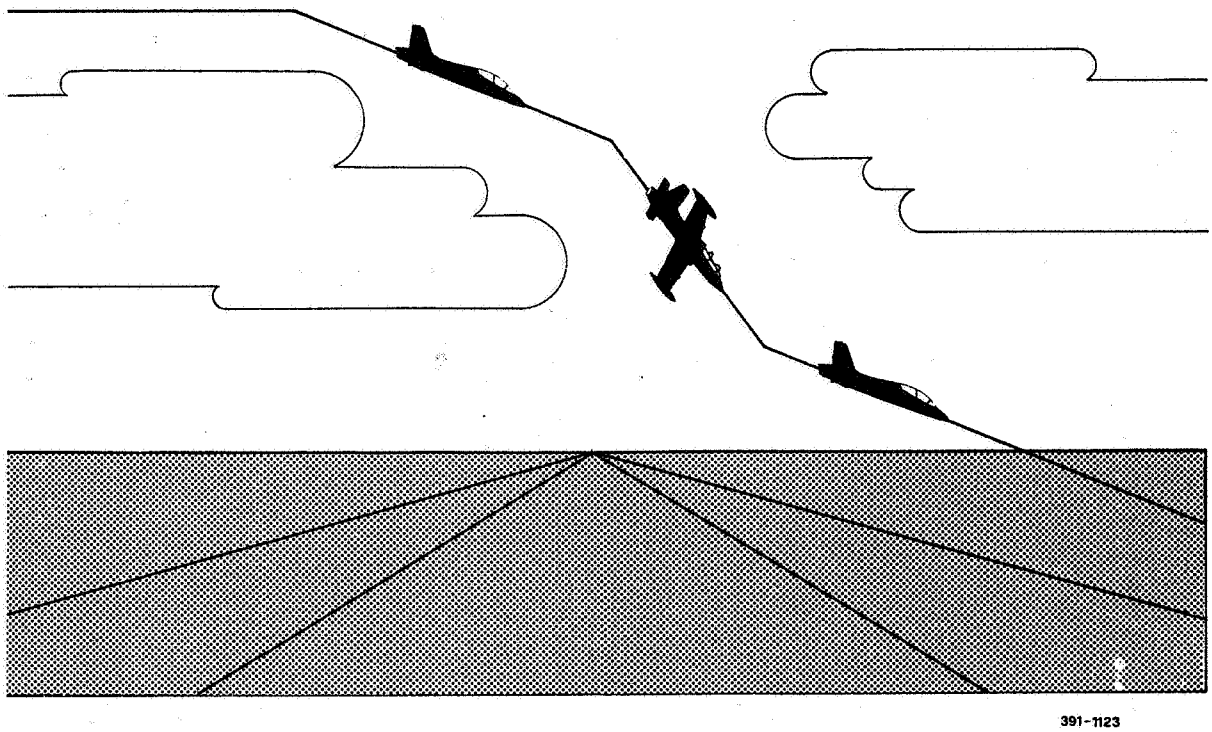


Figure 7-4. IAS Changes During Descend

- When descending from altitudes lower than 10 000 ft, the maximum angle of bank must be 60°, all other established parameters remaining unchanged.
- Under poor visibility conditions (haze, lack of landmarks), it will always be expedient not to fly with excessive bank angles, in order to always have safe control of the aircraft.
- In case of doubts as to the actual attained attitude, bring the wings level and return the aircraft to level flight with the aid of the instruments.
- For the entry and recovery procedures, see Chapter X, Section A, Paragraph 3.
- During prolonged descents, it is necessary to restore the power setting, as RPM tends to decrease with altitude changes.

e. Aided Descent or Instrument Penetration Descent (fig. 7-5)

See FM, Section II.
A descent of this type is mainly used during instrument flying (radar-aided approaches), but it is also very well used when flying VFR (inbound descent after navigation).

Parameters: - 76% RPM
- 250 KIAS
- Speedbrake: OUT

- Carry out the prescribed checks, lower the aircraft nose, reduce power to 76% RPM, wait until the desired airspeed is attained and with a lead of approx. 5 knots on this airspeed, extend the speedbrake.

- Trim the aircraft and periodically restore 76% RPM, as this power tends to decrease as altitude decreases.

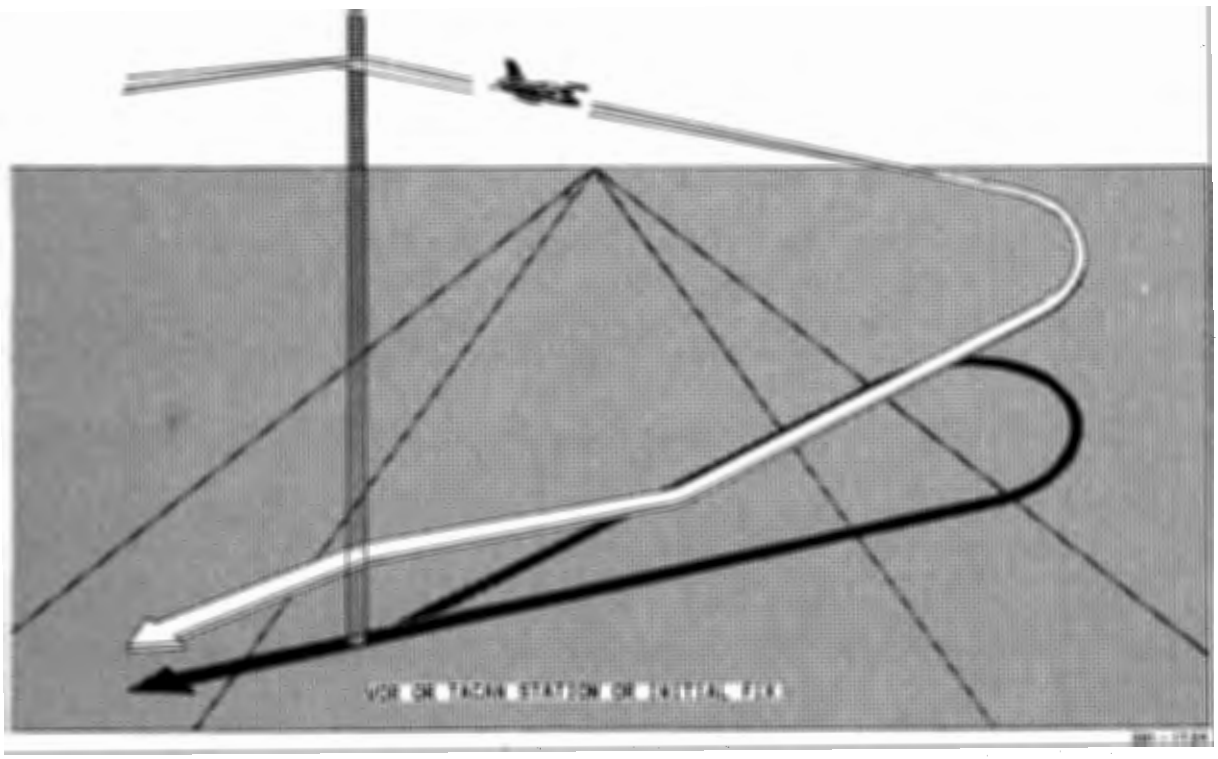


Figure 7-5. Instrument Penetration

NOTE

This penetration is never made from altitudes higher than 25 000 ft. For higher altitudes, see d. rapid descent or c. moderate descent.

f. Descent Planning

(1) Before flying one of the above descents, it is advisable to plan it in advance mentally in order to bring the aircraft to the ground in the most rational and safe way.

(2) The following points are to be considered and evaluated to reach the optimal decision:

(a) Envisaged fuel consumption (see "Performance Data Manual").

NOTE

Average fuel consumption is 1 kg fuel for every 1000 ft of instrument penetration descent.

(b) Position of the airwork area that you are leaving

(c) Position of the reporting point that you must reach (you need to request landing instructions from the tower prior to starting your planning)

(d) Initial and final descent altitude and any intermediate level-off altitudes

(e) Meteo conditions with special reference to the position of cloud formations.

(f) Particular areas to be avoided

g. Level-off after Descent

This is the maneuver that will allow you to stop your descent at a suitable altitude for transition to straight and level flight according to a well defined procedure.

(1) Interruption of descent is to be started with a given lead on the desired level-off altitude. This lead corresponds to 10% of the indicated vertical velocity; with this lead, change the pitch attitude to attain the level flight attitude by applying a light back pressure on the stick.

(2) If the speedbrake is out, it must be retracted 10 kts before reaching the straight and level flight speed, while the engine RPM will be changed with a 5-knot lead.

(3) Suitably adjust the trims as soon as the aircraft is stabilized in level flight

(4) Attitude changes are checked by looking at the outside references, i.e. by evaluating the reciprocal positions of the aircraft nose (instrument panel upper rim or front Pitot heads), against the horizon. Occasional glimpses to the instruments will serve to determine the exact altitude and the airspeed at which retraction of the spedbrake and action on power are required.

(5) Three different procedures can be followed as a function of the descent IAS and subsequent IAS to be obtained in level flight:

(a) Level-off at the same IAS as descent: use 10% of the vertical rate of descent as a lead point to start the maneuver; concurrently re-

tract the speedbrake (if OUT) and increase power to adjust it as required for level flight.

(b) Level-off with final IAS lower than the descent IAS: use 10% of the indicated vertical velocity as a lead point to start the maneuver; maintain the initial power setting 5 knots above the IAS envisaged for level flight, retract the speedbrake (if out), and concurrently change the power setting to adjust it to the level-off IAS (according to what set forth in Chapter VI, para 4).

(c) Level-off with final IAS higher than the descent IAS: use 10% of the indicated vertical velocity as a lead point to start the maneuver; concurrently retract the speedbrake (if out) and increase RPM to adjust it to the IAS required at the end of the maneuver (according to what stated in Chapter VI, para 4).

h. Slow Aided Descent, or Final Approach Descent

See FM, Section II.
This descent is the logical continuation of the instrument penetration. It is preceded by a level flight phase during which speed is reduced and the landing gear extended.
Level-off occurs at an AGL altitude which is a function of the distance of the point at which descent is started from the end of the runway. Since the optimal instrument approach (even if flown visually) corresponds to a descent rate on the glideslope of 300 ft per mile, i.e. a glideslope of 2,82° (2°: 49'), the altitude at which final descent is to be initiated will be:

600 ft AGL at 2 NM from the approach end of the runway

900 ft AGL at 3 NM from the approach end of the runway

1200 ft AGL at 4 NM from the approach end of the runway

1500 ft AGL at 5 NM from the approach end of the runway

1800 ft AGL at 6 NM from the approach end of the runway

2100 ft AGL at 7 NM from the approach end of the runway

In the straight-and-level flight segment that precedes the slow aided descent, the following parameters must be maintained:

- 130 KIAS, AOA 0.47
- T/O flaps
- Landing gear down
- Speedbrake in
- Power as required (approx 80% RPM)

NOTE

Level-off from penetration descent. At the required altitude, trim, maintain 75% RPM and the speedbrake out until 175 KIAS are attained, lower the landing gear, set flaps to T/O, allow the IAS to decrease to 130 knots, retract the speedbrake and apply power to obtain 80% RPM.

At the beginning of final descent, select:

- Flaps DOWN,
- 115 KIAS, AOA 0.45,

- Power as required (from 75 to 80% RPM), to be maintained up to the runway approach end.

2. TRAFFIC PATTERN (fig. 7-6)

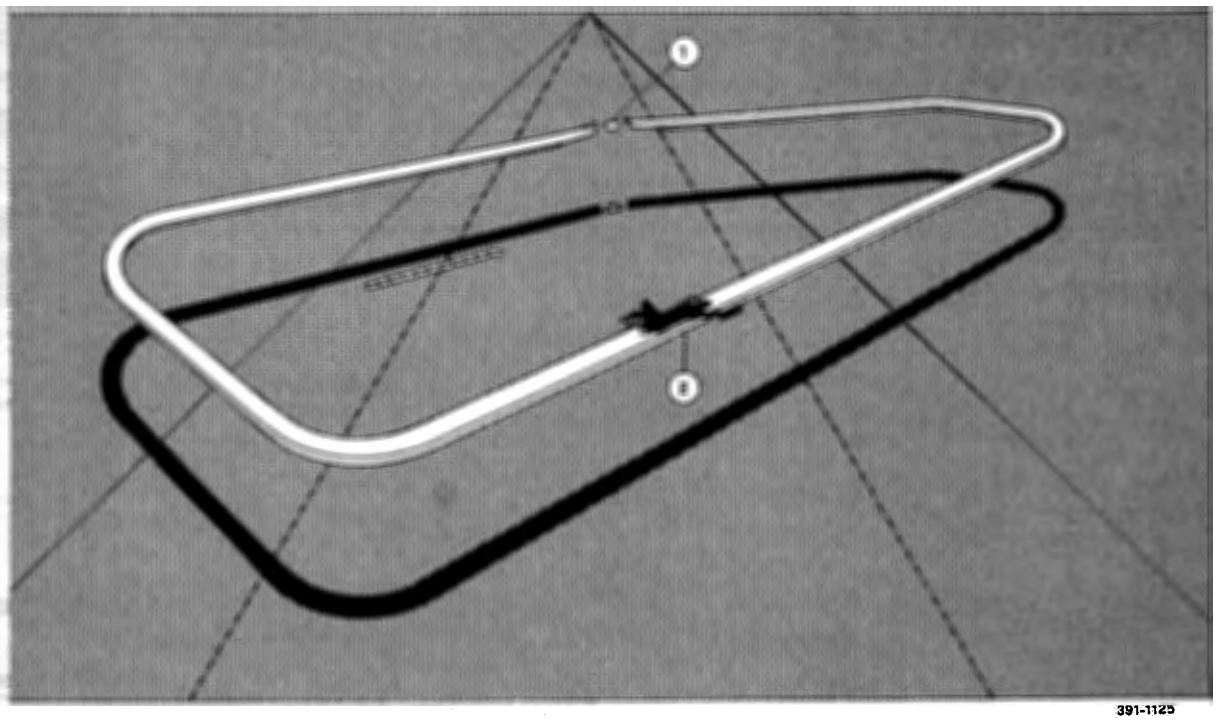
A traffic pattern is an air circuit (well defined in terms of altitude, airspeed and direction), to which there correspond a ground track permitting the aircraft to properly approach the runway for landing. The standard pattern is normally rectangular; occasionally, however, because of special traffic requirements, it can take a different shape.
In this respect, every airport has, depending on its own requirements, one or more patterns that channel the aircraft to bring them safely to the approach for landing.

(1) During approach to the airport for landing, instructions to plan the entry and fly the pattern must be obtained from the tower. The information given by the tower will be as follows:

- Runway in use (QFU)
- Wind direction and velocity (with possible gusts)
- QNH
- Any other information that may be useful for a safe landing

(2) Once descent has been completed, level-off at least 2NM before reaching the pattern, and attain the following parameters:

- AIRSPEED : 250 KIAS
- ALTITUDE : as prescribed for the pattern being flown
- RPM: as required to maintain speed (approx. 78%)



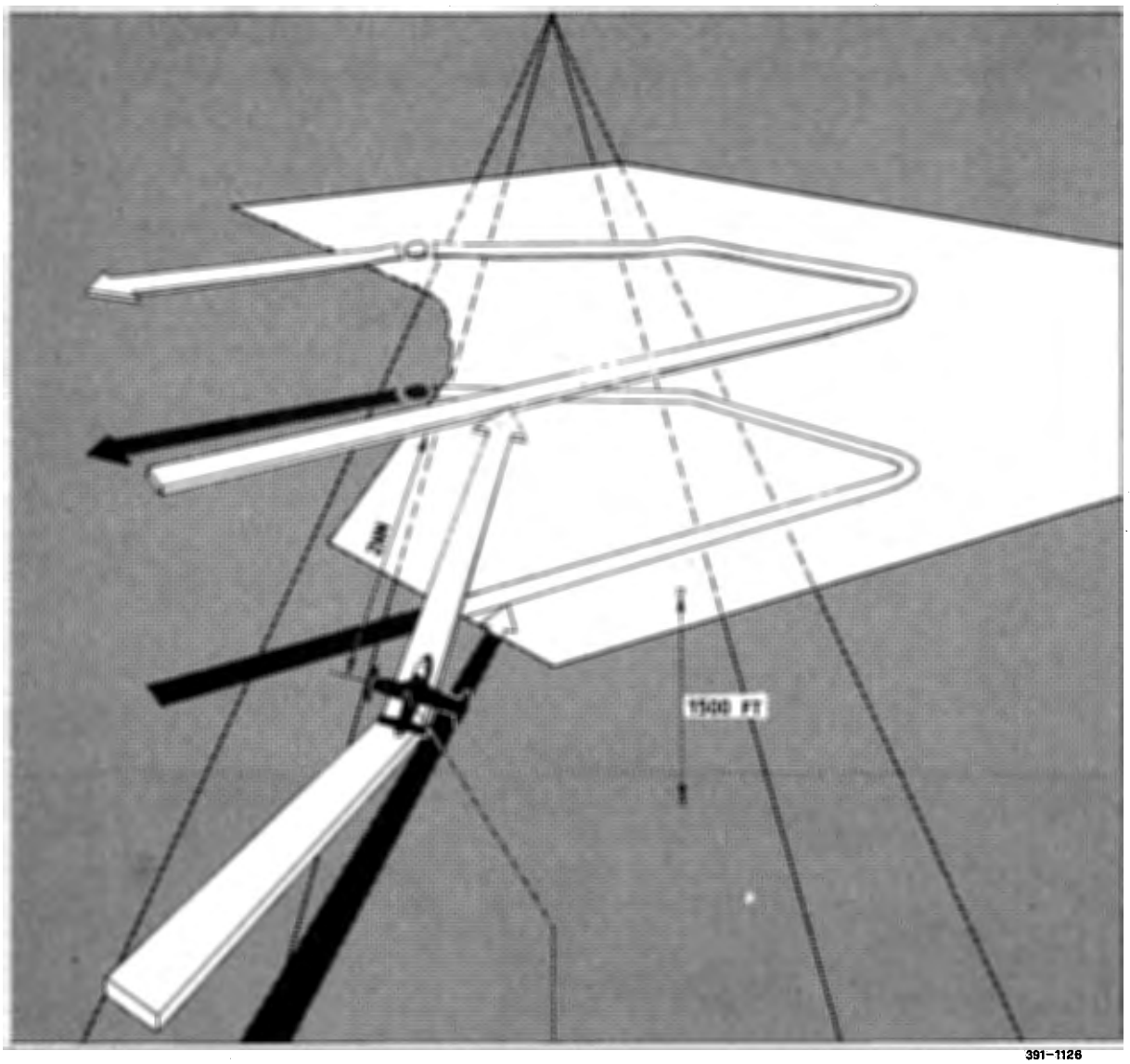
1. INITIAL POINT AT 2,5 NM FROM RUNWAY END
2. IF PERMITTED: 250 KIAS - 1500 AGL
   45° BANKED TURNS

Figure 7-6. Traffic Pattern

a. Entering the Traffic Pattern (fig. 7-7)

This is that special phase of the flight which permits the aircraft to safely enter traffic. Not all pattern points are equally suitable for a safe entry; to meet the safety requirement, entry into the pattern must be such as to permit an easy reciprocal visual contact between the entering aircraft and the traffic already on the pattern.

(1) It can be said that entry into the pattern already starts at the so called "reporting points"; they are located at a suitable altitude and distance from the airport and their purpose is to initially convey and then address the traffic to the most suited section of the traffic pattern for an actual entry into the standard pattern. (Ex. For Jumbo airfield, the reporting points are: overhead the village of..... for QFU XXX at an altitude of 5000 ft QNH; overflying IAS is 250 kt and overhead of .....for QFU XXX at 5000 ft QNH, IAS 250 kt).
When overhead the reporting points, the TWR will be called and informed



250 KIAS; RPM ~82%
1500 FT AGL
DISTANCE FROM PATTERN APPROX. 2NM

Figure 7-7. Entry Into Traffic Pattern

of position and altitude (Ex. Jumbo tower, this is Lion 82, overhead Charlie, 5000 ft ...). On leaving the reporting point, a descent is started (250 KIAS, 65% RPM, speedbrake out), to reach the pattern altitude with the required lead and in the direction of the safest entry.

(2) From the figure it can be seen that the most suited leg for entry is the downwind leg, i.e. the segment delimited by the legs abeam of the runway ends. The envisaged angle for entry is 45° to the pattern.

(3) Other entry possibilities are straight-in entries into initial along the runway heading or along the 45° leg (fig. 7-8).

b. Rectangular Traffic Pattern (fig. 7-9)

As to layout, speed and altitude, the traffic pattern was devised to permit gliding the aircraft to the runway along the most suited QFU (runway heading) if a flame-out should occur at any point of the pattern.

Optimal parameters are:

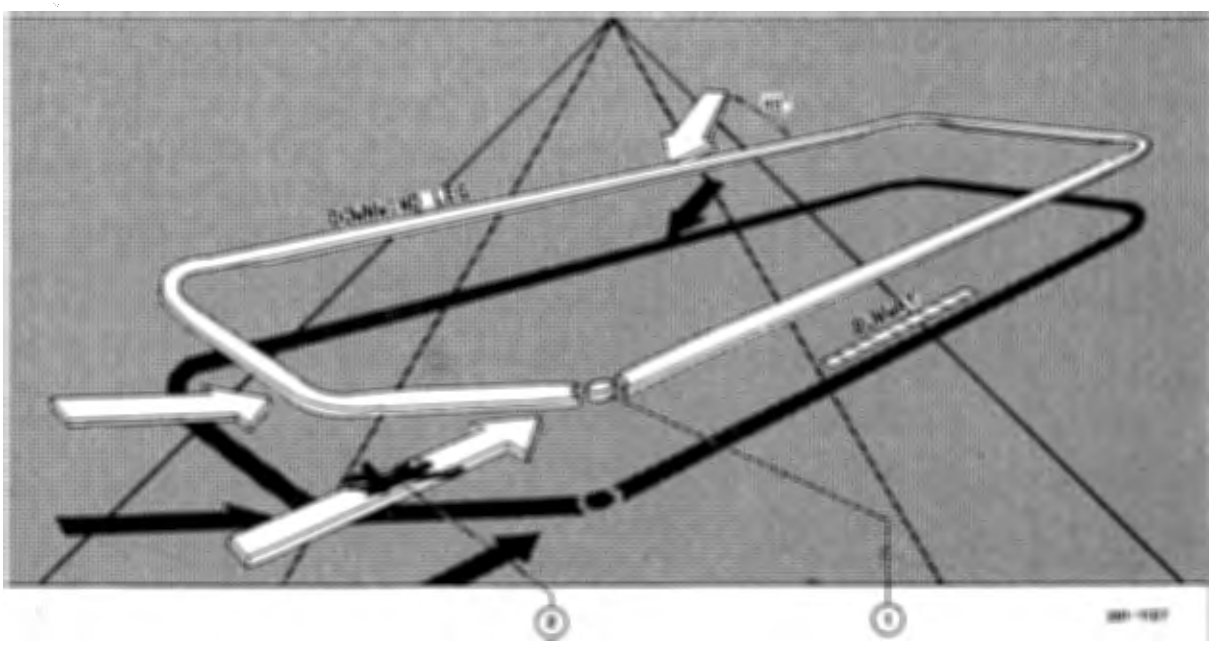
- AIRSPEED: 250 KIAS
- ALTITUDE: 1500 ft AGL, unless otherwise specified by traffic pattern regulations

NOTE

A pattern altitude of 1500 ft QNH may be set for Jumbo airfield (H = 160 ft) to facilitate reading of the altimeter.

- RPM as sufficient to maintain speed (approx. 75%)
- Pattern turn: medium turns (45°)

The circuit consists of the following legs:



1. INITIAL POINT
2. 250 KIAS, 1500 FT AGL

Figure 7-8. Entry Into Traffic Pattern

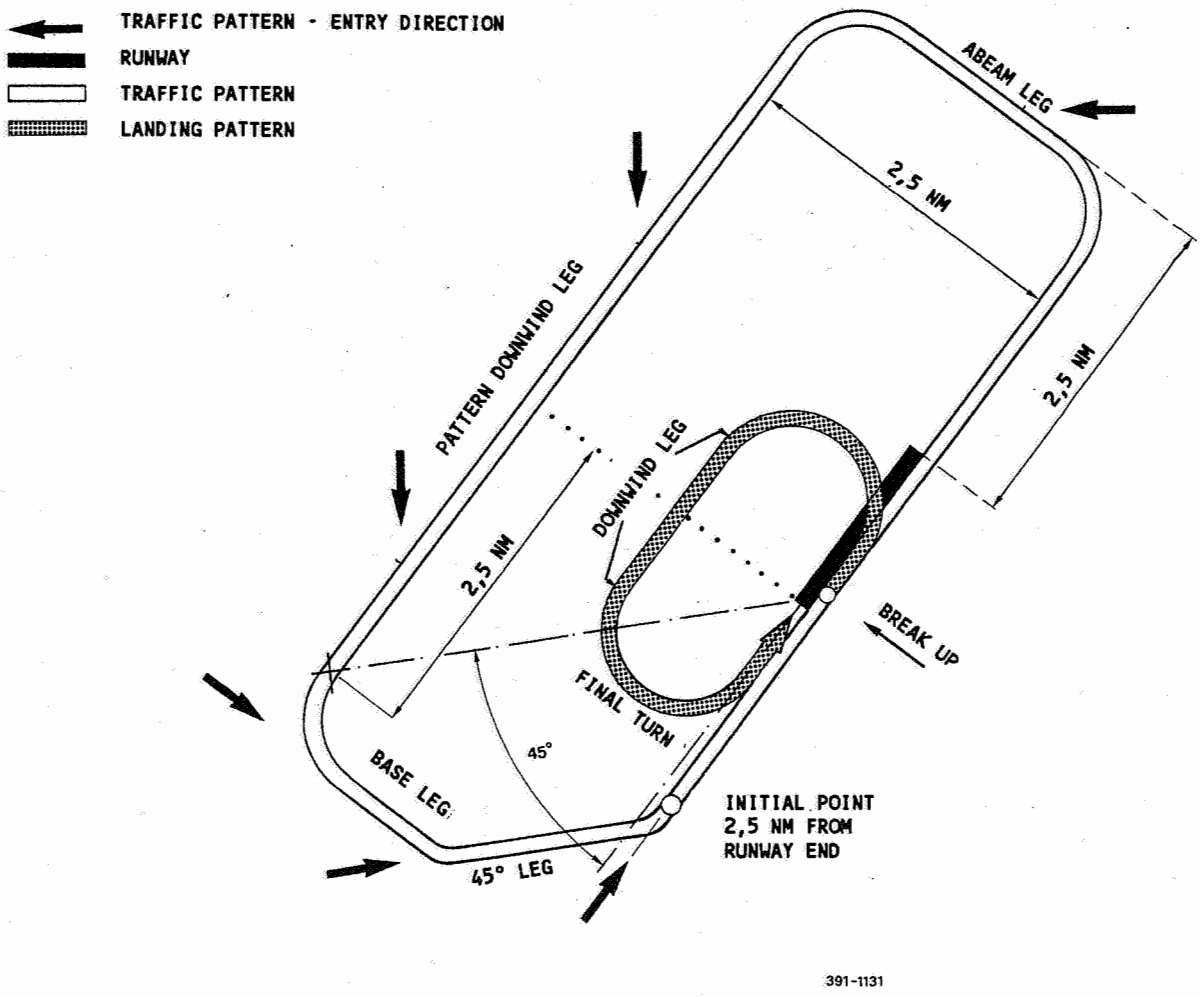


Figure 7-9. Traffic and Landing Pattern Layout

(1) Downwind leg (fig. 7-10): this is a straight leg flown in a direction opposite to the landing direction, which is parallel to QFU (runway in use) and at a distance of approx. 2,5 NM from the runway. From the aircraft, the distance is visualized by having the wingtip brushing the runway side.
When abeam of the runway on the downwind leg, always remember to carry out the cockpit checks (checks envisaged for performance every 10 minutes).

(2) Base and abeam legs (fig. 7-11): these are legs perpendicular to the runway, which precede and follow the downwind leg. In flight the abeam leg starts shortly past the acceleration point, develops in a direction perpendicular to the runway and terminates after approx. 2,5. The beginning of the base leg is at the end of the downwind leg when the runway is sighted under a bearing of 45° aft. Practically from the aircraft front seat, the runway end will be seen opposite the tip tank rear end. The base leg terminates when the initial point is sighted under an angle of 45° (as will be explained later on).

(3) 45° leg (fig. 7-12): this is the leg connecting the abeam leg following the downwind leg to the initial point. The beginning of the 45° leg is to be determined visually by the pilot on the base of the runway threshold position in order to head to the initial point (at approx. 2 NM from the runway end and on the runway extension) with an angle of 45°, and to be ready to bring the aircraft in the direction in which the landing pattern is to be commenced.

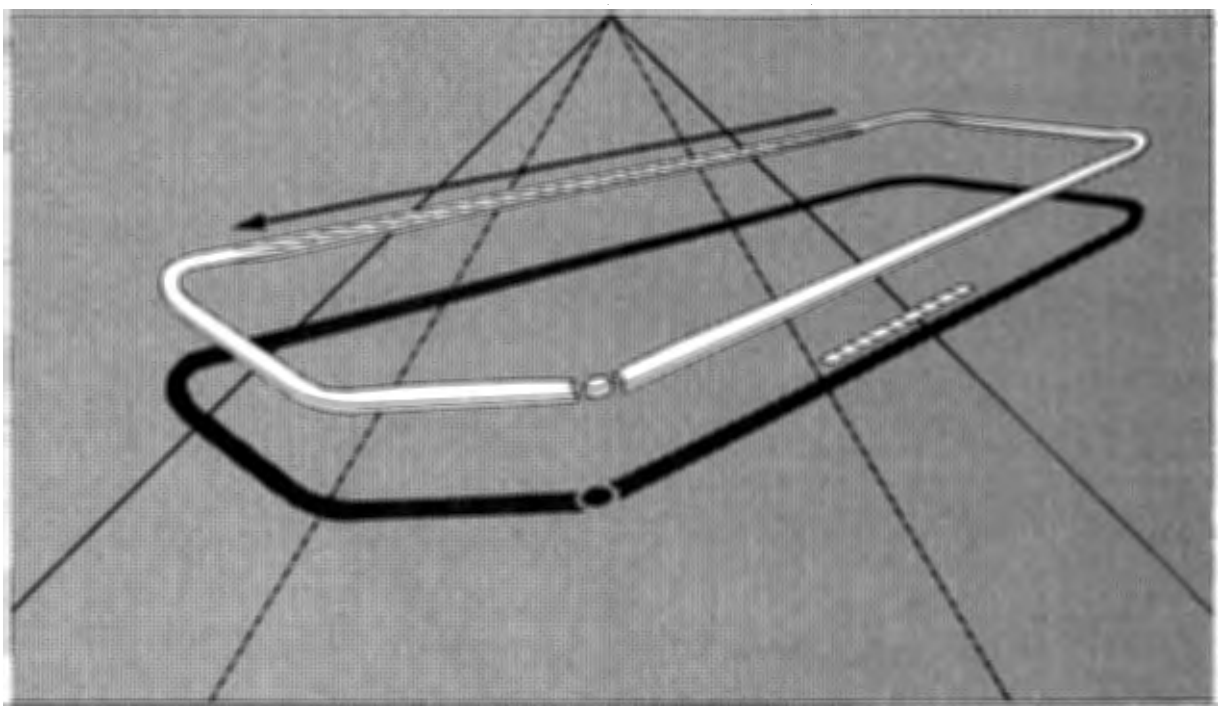


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Figure 7-10. Downwind Leg of Traffic Pattern

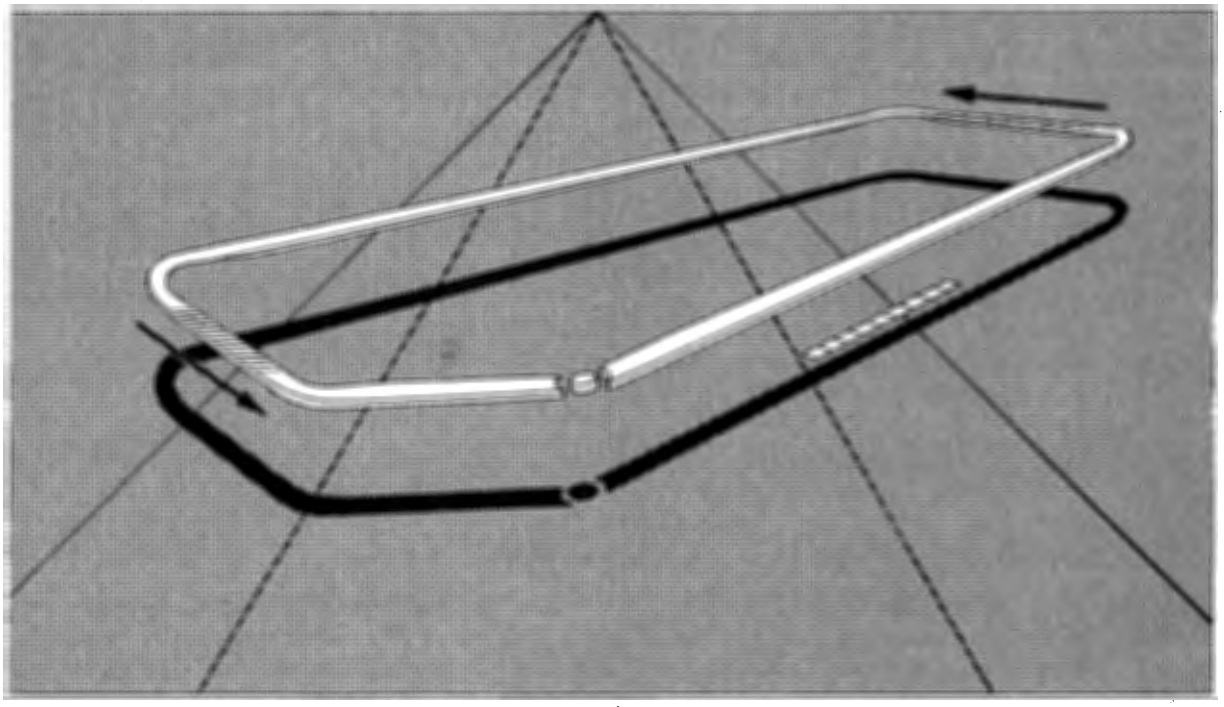

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Figure 7-11. Base and Abeam Legs of Traffic Pattern

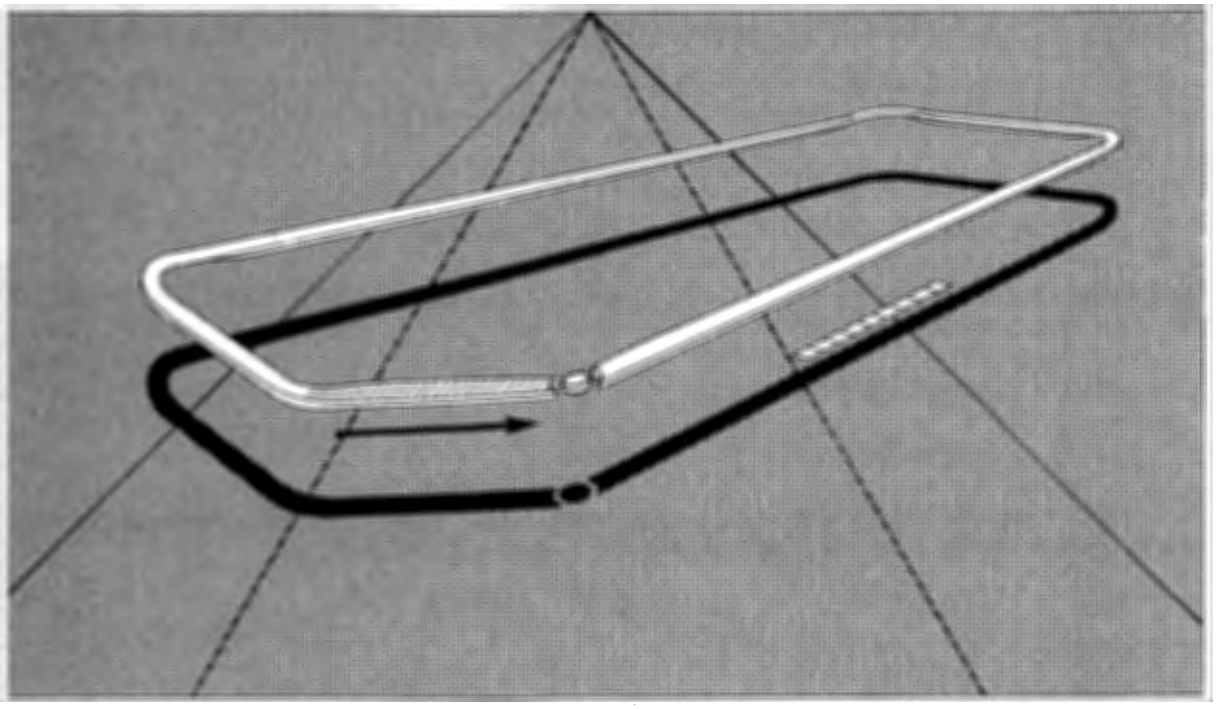

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Figure 7-12. 45° Leg of Traffic Pattern

3. LANDING

a. Radio Communication Phraseology

The conventional abbreviated radio phraseology to call the tower during visual approach and landing is as follows:

- Pilot: Jumbo tower, Lion eight - two, initial point, over (or Jumbo tower, Lion eight two, fuel level low, initial point for full stop, over)

- Tower: Lion eight two, go ahead

- Pilot: (omit Jumbo tower): Lion eight two - breaking out

- Tower: Lion eight two -
  - cleared, you are number one
  - cleared, you are number two
  - cleared, number four at runway end
  - do not break, report on initial

- Pilot: eight two roger. Number four at runway end (or: eight two will report on initial)

After completing the base turn, the pilot must tell his intentions as to landing, namely:

- for full stop landing and runway clearing: "full stop"

- for landing with go around in short final: "go around"

- for landing with go around after touchdown: "touch and go"

- for go around and subsequent entry into normal traffic pattern: "go-around, normal"

- for go around and close traffic: "go-around, tight" etc.

During the final approach the pilot must give the tower the landing gear down and locked signal (three green lights), he says:

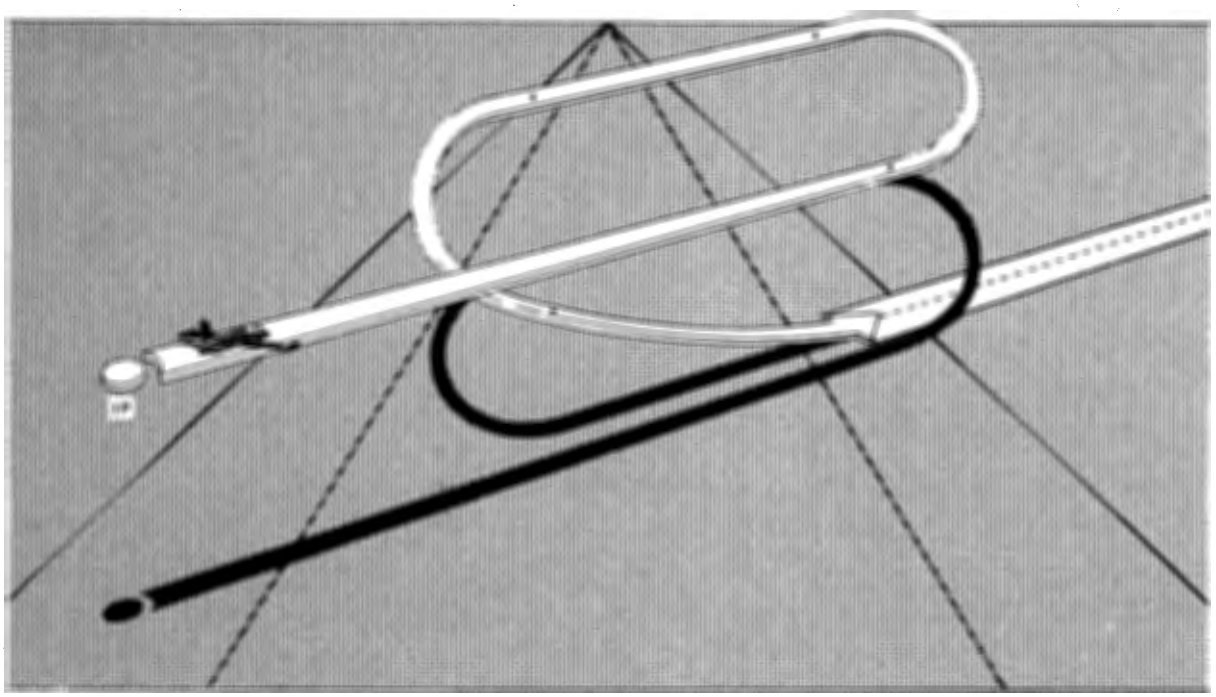
- L.G. DOWN AND LOCKED, FULL STOP, or
- L.G. GEAR DOWN AND LOCKED - TOUCH AND GO

Immediately afterwards he must press the push-button on the engine throttle and hold it depressed for at least 1.5 seconds (see FM, Section I), to transmit the bitonal signal of landing gear down and locked to the ground and the headset.

b. Landing Pattern (fig. 7-13)

A landing pattern is defined as the path that the aircraft flies from the initial point to the touchdown on the runway and includes:

- Initial
- Break
- Downwind leg
- Base leg turn
- Final
- Landing



IP = INITIAL POINT
CALL TOWER
250 KIAS
~78% RPM

Figure 7-13. Landing Pattern

(1) Initial point (IP): it is a mandatory reporting point (call the tower) for the traffic in the pattern and is located 2,5 NM from the end of the runway, along its extension.
From the initial point the aircraft flightpath is straight until overhead the end of the runway, i.e. at the break point; bear in mind that to correctly see this point it is advisable to remain in a slightly external position with respect to the runway (externally to the landing pattern) or take some reference points on the side of this point.

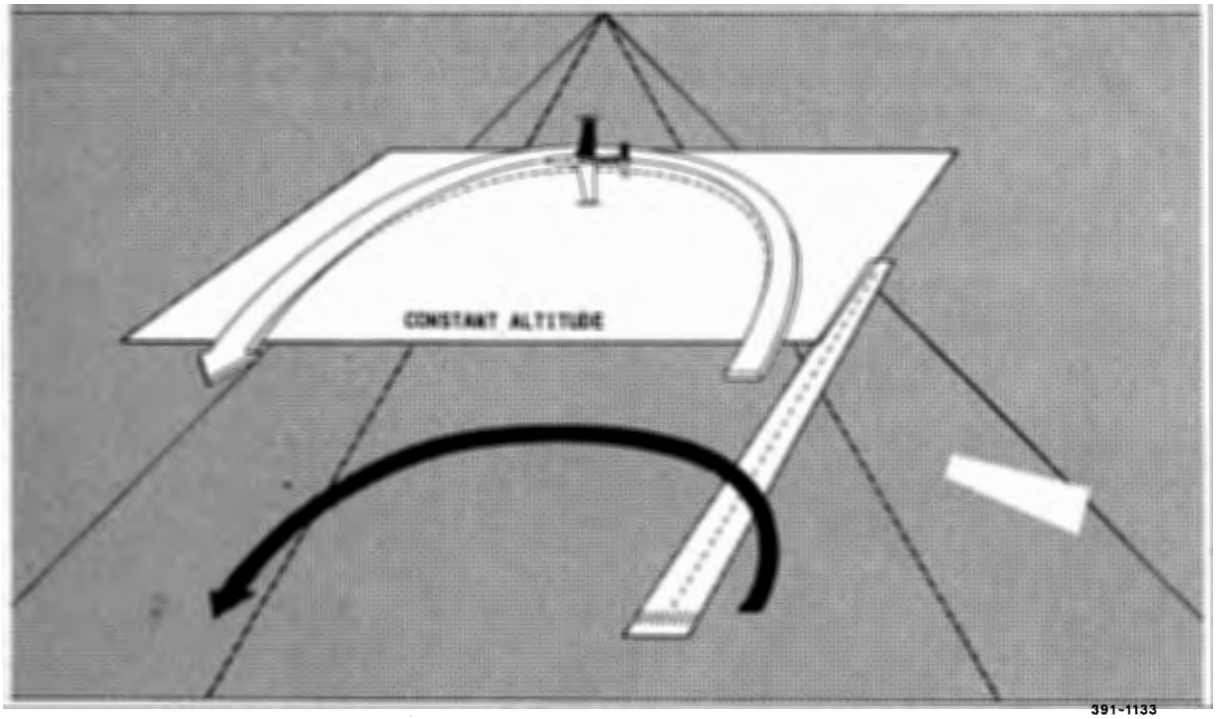
NOTE

On the initial point, radio call to the tower is like this:
Pilot: "Jumbo tower, L. 82, initial point"
Tower: "Roger, cleared"

(2) Break (fig. 7-14): this is a maneuver to be started at the break point; it consists of the aircraft flying a 180° turn with 45° bank and decreasing IAS.

- Once the clearance to break has been requested to and obtained from the tower, move the throttle to 65% (horn), lower the speedbrake, and bank the aircraft 45° to enter the downwind leg

- Bear in mind that clearance to break can be given "at runway end". In this case, the subsequent downwind leg will be longer and it will be necessary to use power to prevent the IAS from dropping below 150 KIAS.



TOWER CLEARANCE
65% RPM AND
SPEEDBRAKE DOWN
45° BANK
DECREASING IAS
TRIM

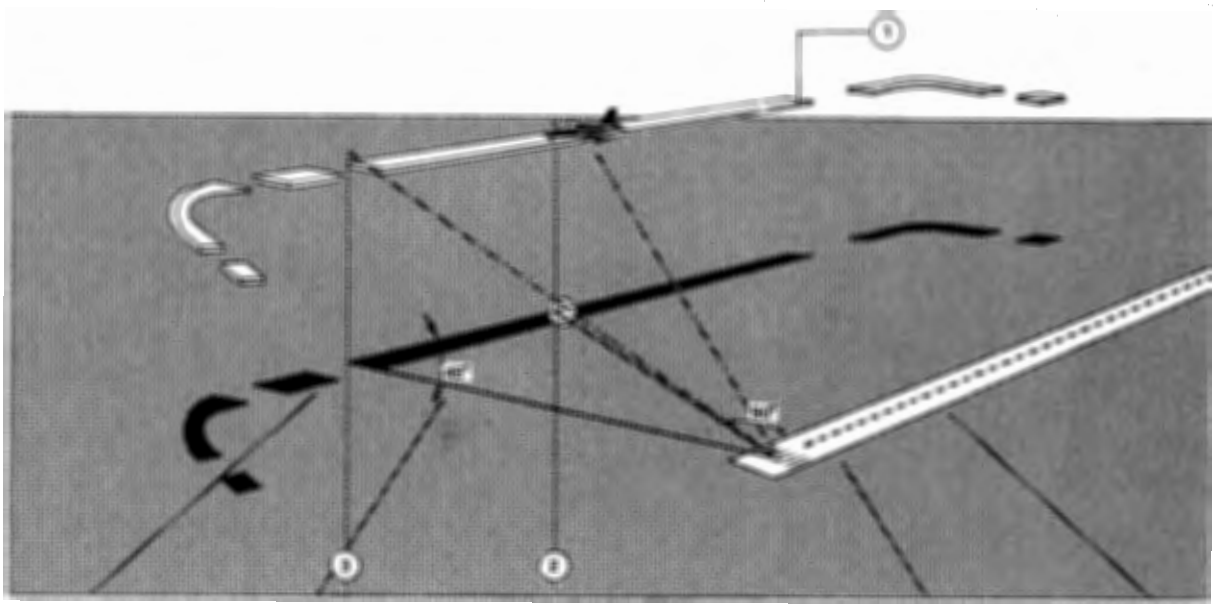
Figure 7-14. Break-up Turn

- During the break, to follow the correct ground track (constant turn radius) it is necessary to gradually reduce the bank angle when the IAS decreases.

- Altitude must be carefully maintained throughout the turn since it will have a tendency to decrease (because of the decreased speed, changed roll attitude and reduced power); In order to counteract the tendency of the aircraft to loose altitude, change its pitch attitude mainly by use of the trim. When you have almost completed the 180° turn, try to assess the aircraft position with respect to the runway so as to roll out onto the downwind leg with a flightpath parallel to the runway (with the necessary drift correction).

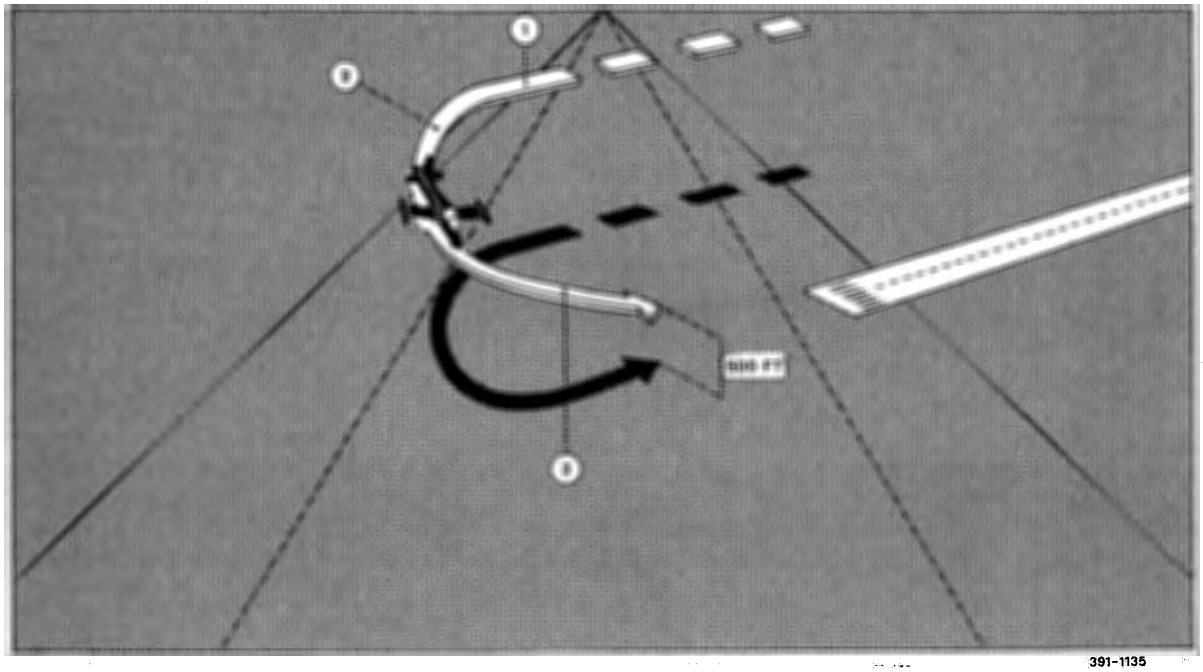
(3) Downwind leg (fig. 7-15): the downwind leg path is very important for a successful accomplishment of the subsequent phases. It is necessary not to converge toward the runway and, in presence of wind, to apply an adequate drift correction to fly the correct ground track. Abeam of the contact point, with a speed of 175 KIAS or less, lower the landing gear, retract the speedbrake and set the flaps to T/O. After checking the indicators and hydraulic pressure gauges, apply power to maintain an airspeed of 140 KIAS. Continue flying downwind until you can see the runway end 45° aft, i.e. when the runway appears under the wing trailing edge.

(4) Base leg turn (fig. 7-16): this is the descending turn that connects the downwind leg to the extension of the runway.
At the end of the downwind leg, set the throttle to 70% slightly lowering the aircraft nose; at the same time move the flaps to "DN" and check the indicator. Start a turn with a bank angle of approx. 30°, maintaining an airspeed of 130 KIAS plus correction (1,5 kt every 100 kg beyond 400 kg of fuel on board).
After flying the first 90° of the turn, adjust the bank for the existing wind conditions or possible path errors so that at the end of the turn the aircraft is aligned with the extension of the runway centerline.



1. START OF DOWNWIND LEG; IAS DECREASING
2. ABEAM OF CONTACT POINT; 170 KIAS, LANDING GEAR DOWN, SPEEDBRAKE IN, CHECK LANDING GEAR AND INDICATORS; FLAPS T/O, RPM APPROX. 75%
3. FROM ABEAM LEG TO 45° AFT: 140 KIAS AND 70% RPM
   FLAPS DOWN: TRIM AND MAINTAIN ALTITUDE

Figure 7-15. Downwind Leg



1. 140 KIAS
   T/O FLAPS
   ~70% RPM
2. 130 KIAS - FLAPS DOWN
   TRIM; TAXI LIGHT;
   RADIO CALL; LOOK AT A/C AHEAD
3. AGAIN CHECK LANDING GEAR DOWN

Figure 7-16. Base Leg Turn

For an optimal rollout on final approach, the base leg turn must not be completed below 500 ft.
Bear in mind that in presence of other landing traffic, it is not permitted to start the base leg turn if you do not have the aircraft in front of you in sight.

- After completing the base leg turn, it is mandatory to repeat the cockpit checks, with special attention given to the landing gear and flap checks.

(5) Final (fig. 7-17): it is the straight path bringing the aircraft from the base leg turn to the threshold of the runway.
After completing the base leg turn, check again:

- Landing gear down and 3 green lights on
- Flaps DOWN

Switch on the taxi light and call the tower: "Lion eight two on final", then operate the bitonal landing gear signal.
The final approach is characterized by a constant rate of descent. For a correct final approach the aircraft nose must be aimed at the runway end and be approx. 20° below the horizon.
The speed envisaged for final is decreasing: from 130 KIAS at the end of the base leg turn to 115 KIAS on short final.
The above values refer to a landing with 250 kg or less of fuel weight on board and no wind.
The final approach with more than 250 kg of fuel remaining on board must be flown at a speed of 1,5 knot higher for every 100 kg in excess of 250 kg.

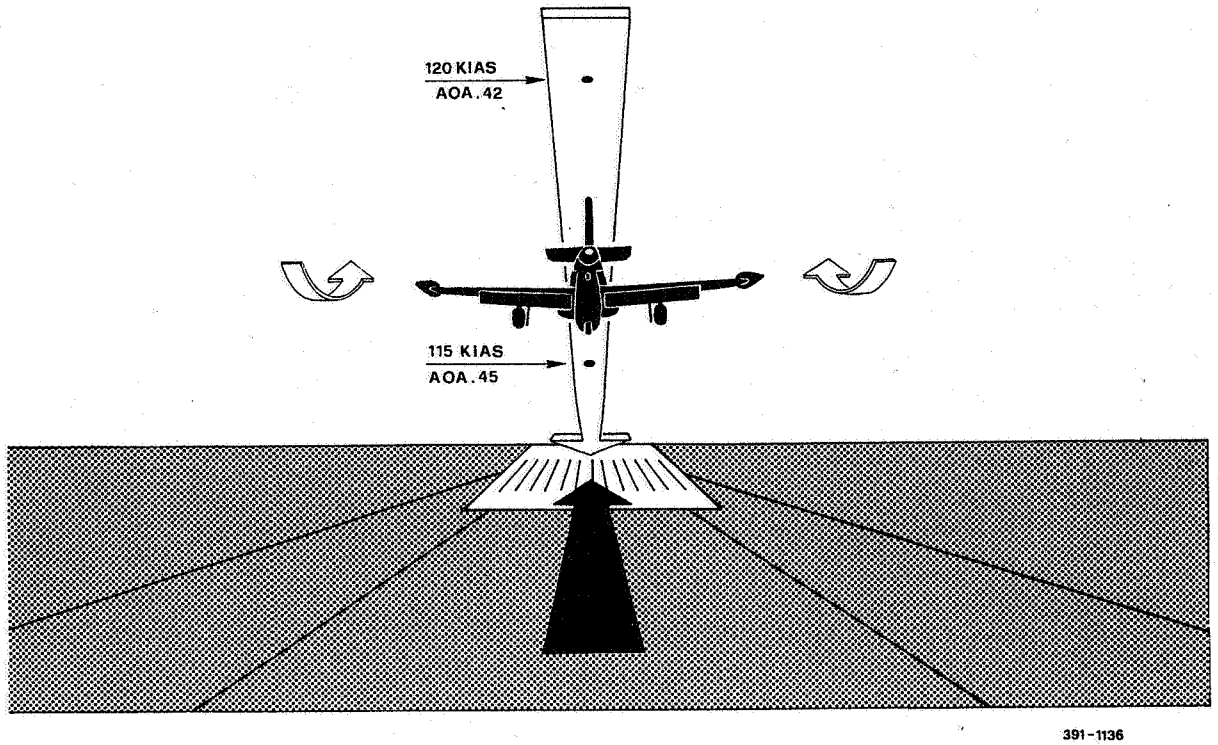


Figure 7-17. Final

NOTE

The AOA indication goes from an initial value of 0.40 to the short final value of 0.45, irrespective of the aircraft mass.

Speed corrections are to be applied also in presence of gusty wind (fig. 7-18).
In this case, to the normal correction there will be added the correction for gusts, equal to half the gust velocity (ex. 20-knot wind with 30-knot gusts. Correction will be + 5 knots to be added to the KIAS).
In any case, an airspeed of 135 KIAS will never be exceeded, nor should airspeed drop below 110 KIAS.
The presence of wind also affects the ground track during the landing pattern.
From the initial point to break, from break to the downwind leg and from the downwind leg to final, the accelerations produced by the wind must be taken into account, and the pilot will apply corrections both while flying straight legs (crab into the wind technique) and in turns (variation of wing bank angle).

- To adequately establish the amount of drift, it is sufficient to take a reference on the horizon and check that the aircraft is constantly heading toward it.

- As to the final approach under wind conditions, a combination of wing low and crab method can be used.
The difficulty of keeping the controls crossed suggests however that the second technique be avoided in the initial phase of training.

c. Variants to Standard Final Approach

Small and continuous adjustments may be made during the approach in

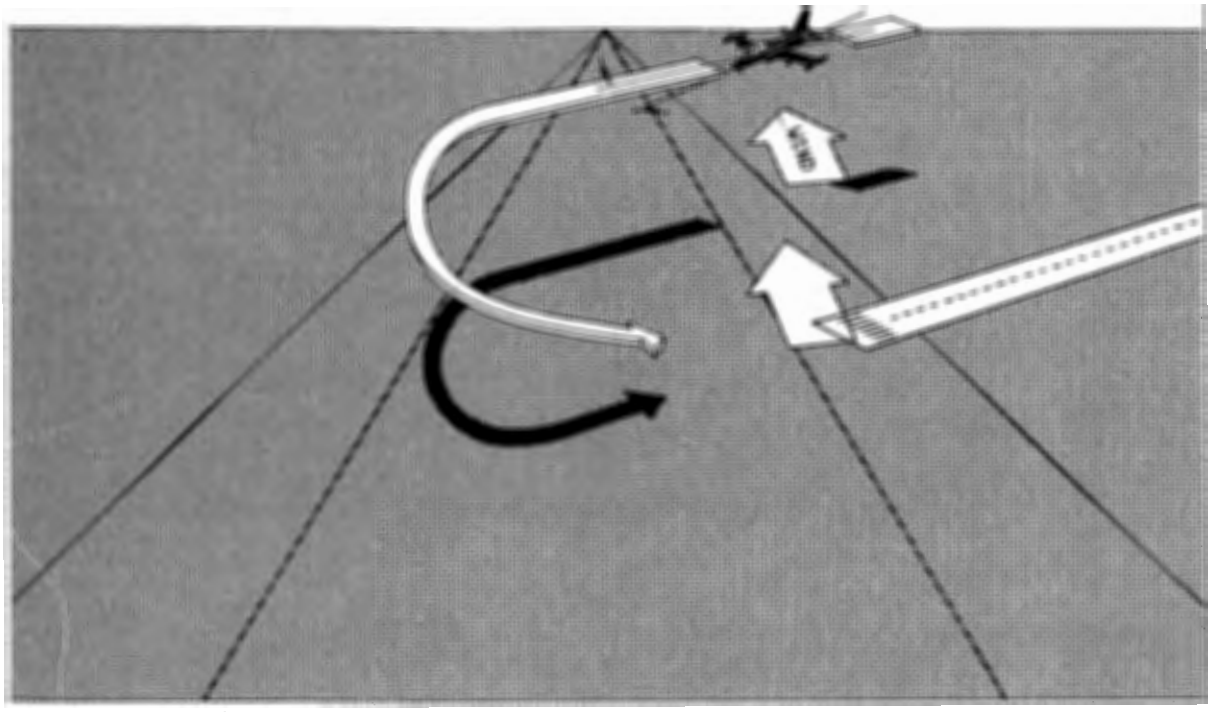


Figure 7-18. Crosswind Final Approach

order to maintain the rate of descent and approach direction. The combined use of stick and throttle must be made so as to prevent the latter from being retarded beyond 60% RPM not to create difficulties if a rapid increase in engine speed should be required.
To meet special requirements, the approach can be flown with a steep or shallow flightpath; a steep or flat approach will thus respectively be obtained.

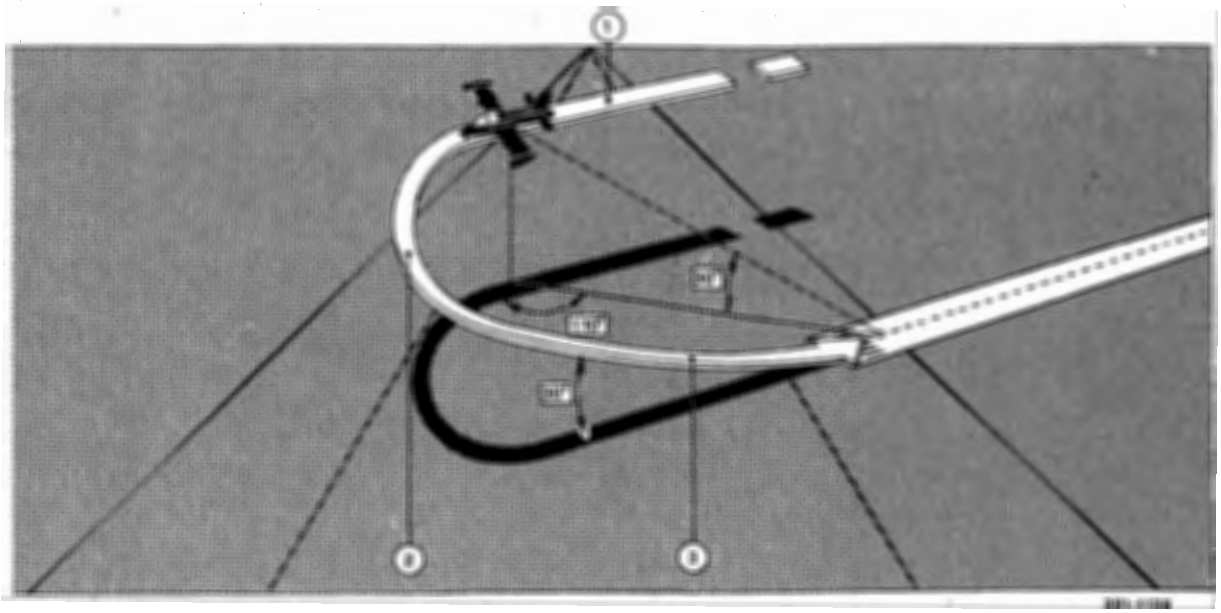
(1) Steep approach (fig. 7-19): it is carried out to train the student pilot to land with no use of the throttle; for this to be done, it is evident that descent must be started at such an altitude and distance as to permit gliding the aircraft to the touchdown point. The most apparent characteristic of this approach is the high rate of descent. The aircraft nose points to the runway end with an angle of approx. 30° below the horizon.

(2) Flat approach (fig. 7-20): this approach is flown to train the student pilot to types of approaches used in particular aircraft or to meet special landing requirements (short landing). The main characteristics of this maneuver are the many power setting changes, low descent rate, constant and precise speed control, peculiar attitude (nose 10° below the horizon) with the aircraft nose pointing short of the runway end.

d. Normal Landing (fig. 7-21)

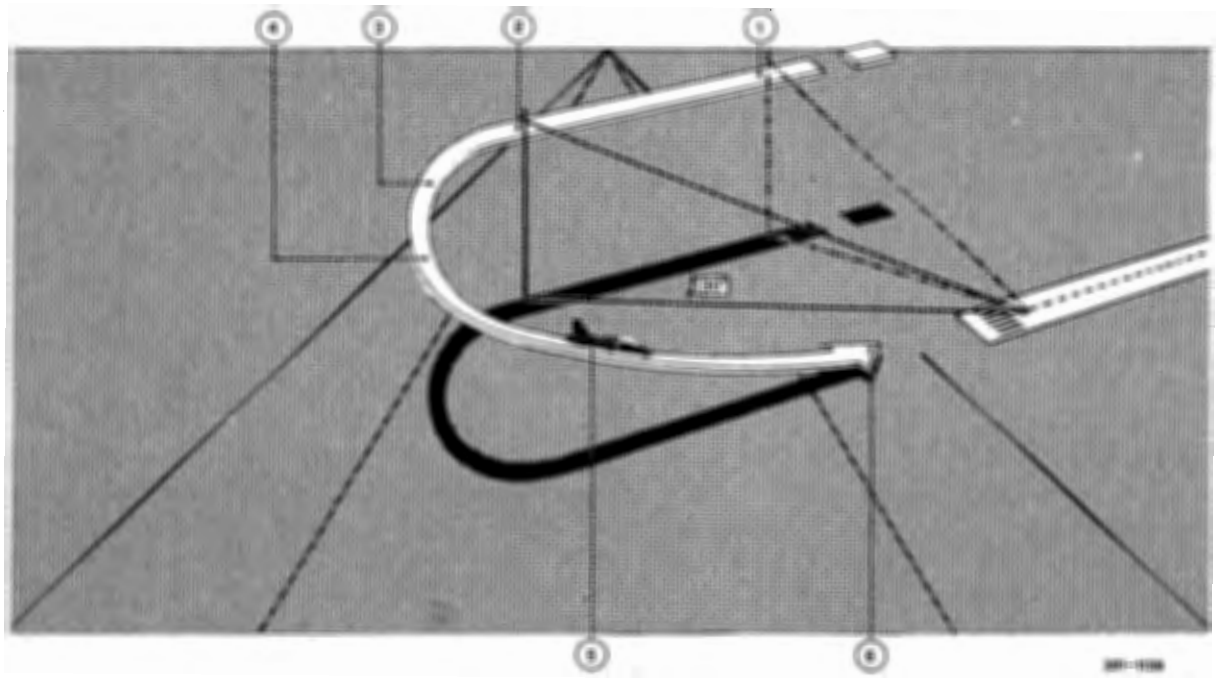
This is the maneuver permitting the aircraft to be brought to a smooth touchdown at the minimum flying speed. The maneuver is divided into three main phases, namely: roundout, flare and touchdown

(1) Roundout (fig. 7-22): it is the transition phase from the final approach attitude to the flare attitude. If the approach airspeed is correct and the flightpath is as prescribed, the attitude change will be smooth and such as to bring the aircraft to overfly the runway with a fairly flat attitude and at very low altitude. In this phase, when posi-



1. ABEAM OF TOUCHDOWN POINT: 170 KIAS, LANDING GEAR DOWN; SPEEDBRAKE DOWN; 150 KIAS, THEN FLAPS DOWN; LANDING GEAR AND FLAPS CHECKS
2. TRIM; CALL TOWER
3. LANDING GEAR CHECK: 115 KIAS

Figure 7-19. Steep Approach



1. ABEAM TOUCHDOWN POINT:
   - 170 KIAS
   - LANDING GEAR DOWN
   - SPEEDBRAKE IN
   - 3 GREEN LIGHT ON
   - ADJUST RPM TO OBTAIN 140 KIAS
2. BEFORE TURNING:
   - 140 KIAS
   - FLAPS FULL DOWN
3. 130 KIAS
4. TRIM:
   - WATCH OUTSIDE
   - CALL TOWER
5. FINAL:
   - 80%
   - 115 KIAS
   - AGAIN CHECK LANDING GEAR
   - TAXI LIGHT ON
6. SHORT FINAL:
   - 110 KIAS

Figure 7-20. Flat Approach

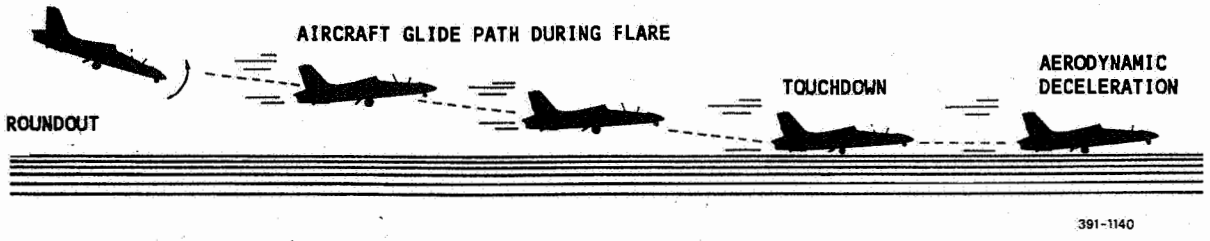


Figure 7-21. Roundout and Touchdown

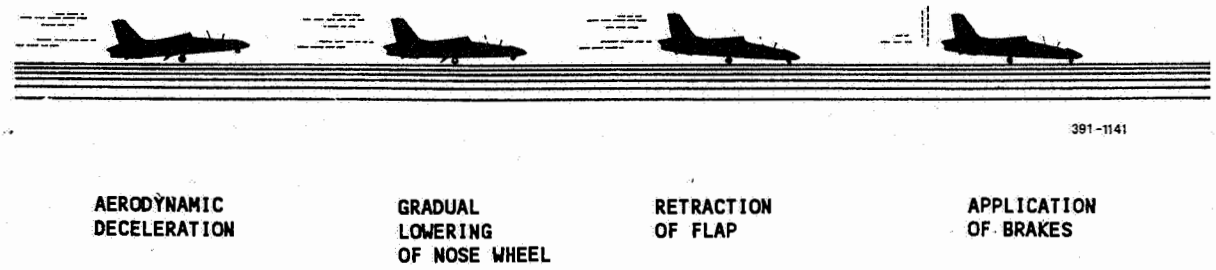


Figure 7-22. Normal Landing

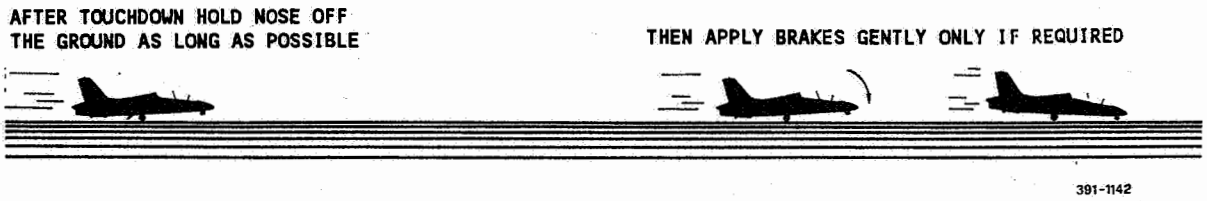


Figure 7-23. Landing on Slippery Runway

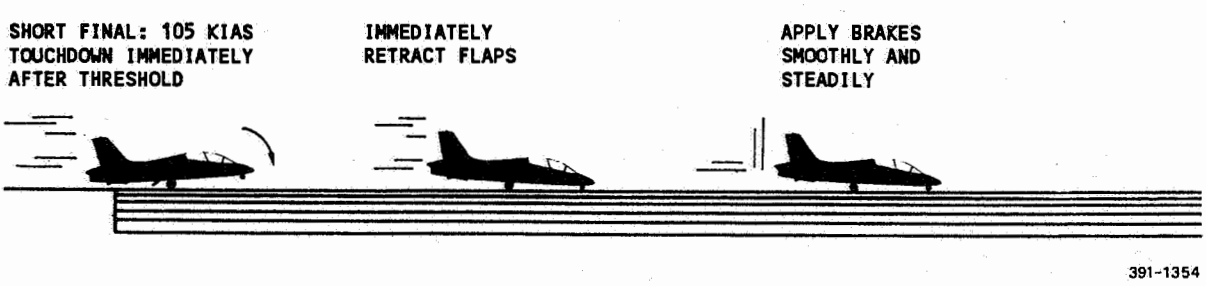


Figure 7-24. Landing on Short Runway

tively over the runway, the throttle will be slowly retarded to IDLE and flare will begin.

(2) Flare: it is the phase in which the aircraft "floats" at very little distance from the runway, with decreasing airspeed and continuously changing angle of attack to compensate for the loss of lift involved by the decrease in airspeed. The errors to avoid in this phase are:

- An excessive or abrupt pullup that makes the aircraft fly off the ground with consequent sudden speed drop and heavy touchdown on the runway.

- A delayed pullup that can result in a heavy three-point touchdown or even in a touchdown on the nosewheel.

- A pullup with the wings not at level, which causes the aircraft to skid to the runway side and contact the ground on one wheel.

In all above cases, permanent deformation or failure of the aircraft structure may result.
Lifting the aircraft again off the ground must however be absolutely avoided. It is recommended that a frontal-lateral view be used rather than a frontal view only in consideration of the peculiar aircraft attitude in this phase. It is thus possible to better evaluate the height over the runway.

(3) Touchdown: touchdown must take place in the center of the runway. If the flare has been flown correctly, the aircraft will contact the ground gently on the main wheels.

After touchdown, maintain a nose-high attitude for a correct aerodynamic braking to be obtained.
As speed decreases, (80 KIAS), the nosewheel will be settled gently onto the runway and the flaps moved to UP. Maintain directional control by use of the rudder pedals and apply the brakes smoothly and steadily; as speed dissipates further, the braking action can be increased with no danger.
The use of the brakes requires special attention. If the nose is lowered at too high a speed (85 to 90 kt), the aircraft in the flaps-down configuration still has some lift and an abrupt application of the brakes may cause tires skidding and even bursting.

This situation is usually worse in presence of crosswind. If the stick is not moved upwind, the aircraft weight will be on one wheel, with very little weight on the other wheel which could skid because of the braking action and burst.
Therefore, in presence of crosswind, before applying the brakes, it is necessary to balance the weight on the two wheels by moving the stick upwind. At low speed (taxi speed), with rudder pedals centered, engage the steering.

If the runway length permits a normal ground run, try to establish an aerodynamic deceleration on landing so as to use the brakes only when the aircraft has all its wheels on the ground and speed has already been partly dissipated; this to avoid creating vibrations on the nosewheel, to reduce brake wear and the probability of tire overtemperature with consequent bursting.
As far as the optimal braking action is concerned, remember that if the wheels should skid on the ground the pressure must be fully and momentarily removed from the toe pedal (a partial release of brakes is not sufficient), and then reapplied.

e. Landing on Wet or Icy Runway or with Brake Failure (fig. 7-23)

(1) Fly an aided approach (same as for short runway with possible speed corrections)

(2) After touchdown, hold the nose as high as possible and as long as possible (70 KIAS)

(3) After the nosewheel is lowered, move the flaps to UP, and apply the brakes smoothly and steadily, using the emergency brake where required.

(4) If necessary, request barrier engagement

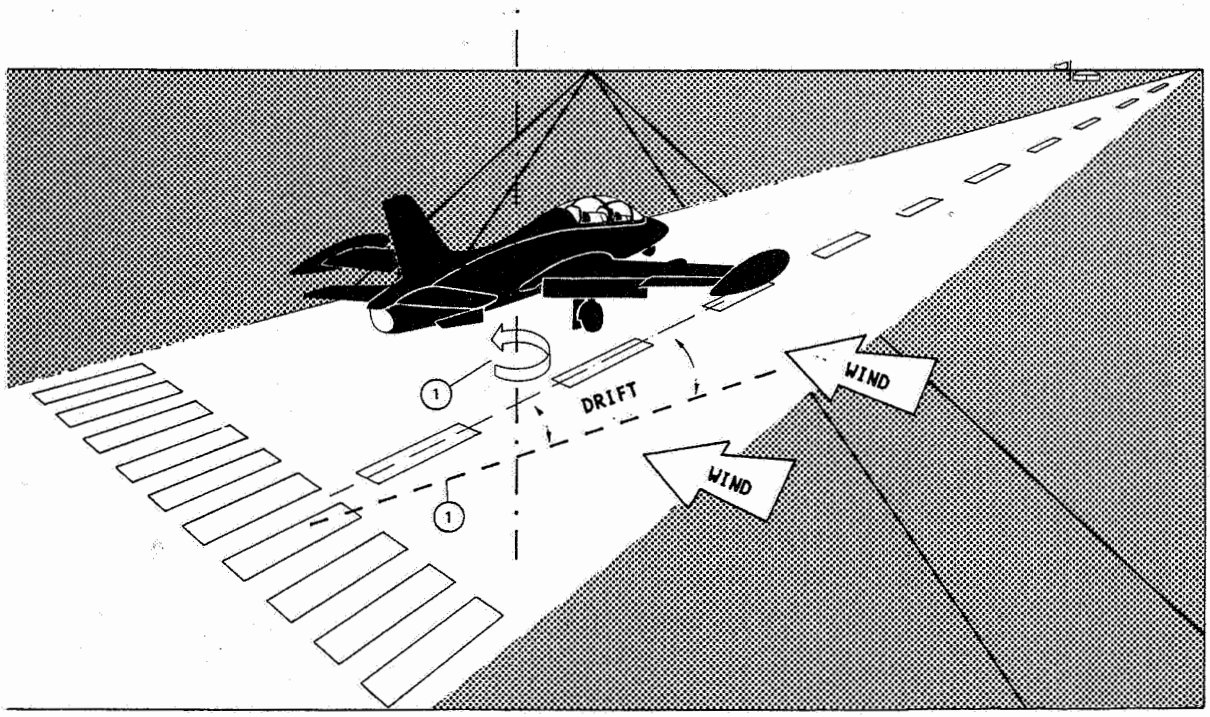
(5) At a speed close to taxi speed, engage the nosewheel steering.

f. Landing on Short Runway (fig. 7-24)

Come to landing with reduced fuel load (less than 400 kg) and fly a longer downwind leg to permit a subsequent aided final with power on and minimum safety speed (105 KIAS).
Touchdown immediately past the runway threshold, lower the aircraft nose and concurrently retract the flaps. As soon as the nowewheel touches the runway, move the stick forward, and sideward in case of crosswind. Apply the brakes smoothly and steadily taking care to avoid locking the wheels. When entering a relatively low speed range, the braking action can be increased. The aircraft will stop in a short space (450 meters approx.).

g. Crosswind Landing (fig. 7-25)

During the approach phase, counteract drift by crabbing into the wind,

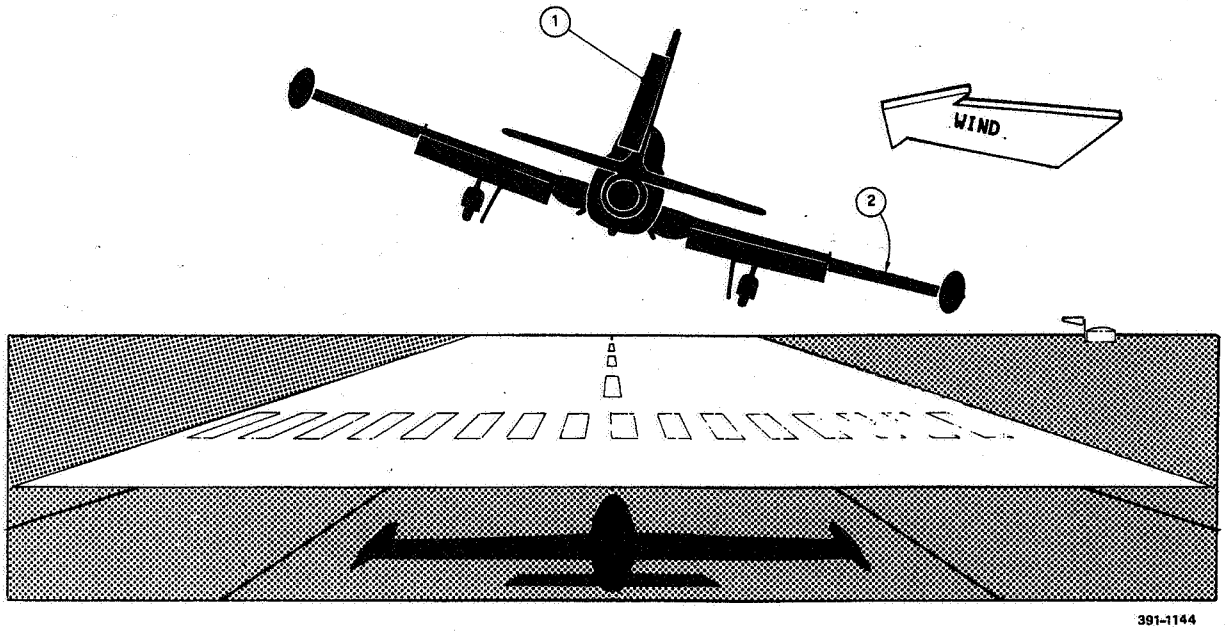


391-1143

1. CRAB TO CORRECT FOR DRIFT IN ORDER TO MAINTAIN FLIGHT PATH PARALLEL TO RUNWAY

2. FINAL ACTION: ACT ON PEDALS TO ALIGN THE AIRCRAFT LONGITUDINAL AXIS WITH THE RUNWAY CENTERLINE

Figure 7-25. Crosswind Landing



1. WIND FROM RIGHT: APPLY LEFT RUDDER
2. WIND FROM RIGHT: LOWER RIGHT WING

Figure 7-26. Landing With Strong Crosswind - Final

maintaining a flightpath alignment with the runway.
Continue like this until just before touchdown, then act on the rudder pedals to align the aircraft longitudinal axis with the runway centerline. After touchdown, move the stick upwind and maintain directional control with the rudder.
In case of particularly strong crosswind, the above technique would result in aircraft skidding on touchdown, with subsequent lateral loading applied on the two main landing gear wheels. Since the wind effect is particularly noticeable during flare and pullup because of the continuously decreasing IAS, to remove the above reported problem it is advisable to gently bank the aircraft upwind during flare, taking care to maintain the aircraft longitudinal axis parallel to the runway centerline by opposite rudder application (fig. 7-26).
In presence of strong crosswind, once the nosewheel has been lowered onto the runway, it is essential that the flaps be immediately retracted to obtain better aircraft control.

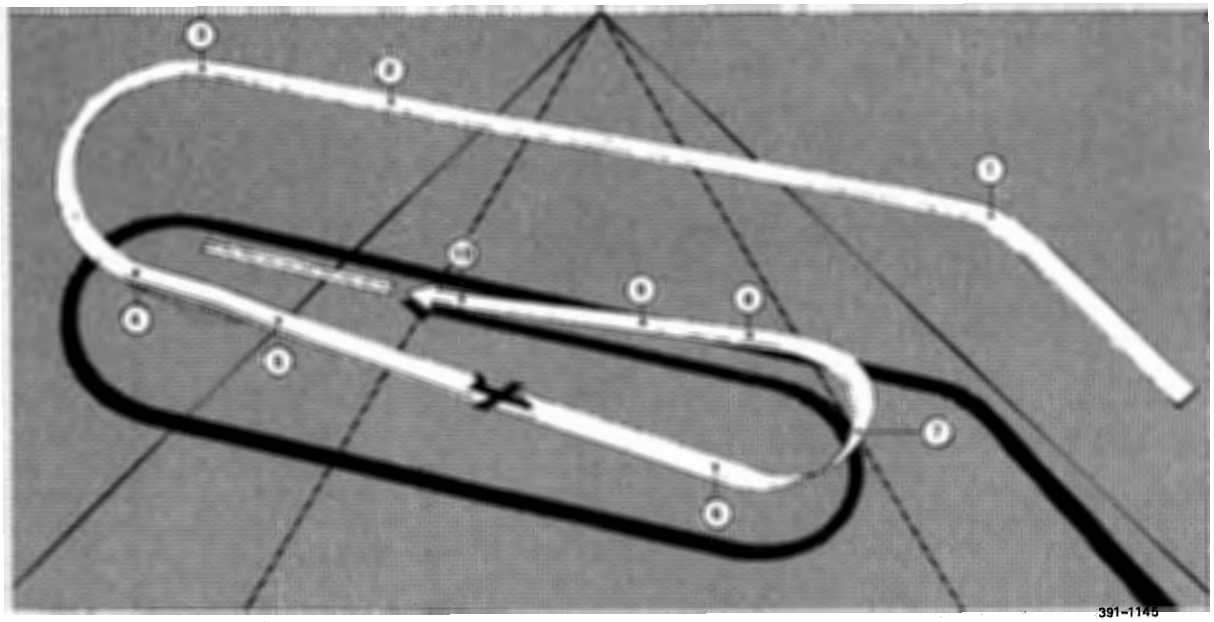
h. No Flap Landing (fig. 7-27)

This is a procedure permitting a safe landing in case of flap failure. For this procedure, the landing pattern is modified with respect to the normal pattern.

(1) On initial (1500 ft-230 KIAS), make the prescribed radio call to the TWR.

(2) On break point, reduce power to 60% RPM, then call the tower and go straight to the runway end, then break with a bank angle of 45° without lowering the speedbrake.

(3) After completing the turn, fly parallel to the runway and hold altitude; as soon as speed is below 175 KIAS, lower the landing gear holding the altitude and the power setting; wait for the IAS to go down to



1. INITIAL POINT: 250 KIAS, 1500 FT, CALL TOWER TO REQUEST A "NO-FLAP LANDING"
2. ABOVE END OF RUNWAY END: REQUEST A END OF RUNWAY"
3. BREAK-UP WITH SPEEDBRAKE IN, 45° BANK
4. 175 KIAS, LANDING GEAR DOWN AND CHECK
5. 150 KIAS RESTORE 60% RPM AND START DESCENT
6. 140 KIAS AND 1000 FT, ABEAM OF INITIAL POINT, TURN
7. 140 KIAS, ADJUST RPM AND AGAIN CHECK LANDING GEAR DOWN
8. 120 KIAS AND 600 FT
9. 120 KIAS, TAXI LIGHT ON
10. 120 KIAS

Figure 7-27. No-flap Landing

150 kt. From this moment, while maintaining direction, IAS and RPM, descend to 1000 ft attaining a position approx. abeam of the initial point.

(4) Fly the base leg turn at 140 KIAS plus corrections. If required, adjust power to avoid ending the turn below an altitude of 600 ft.

(5) Final is shallower than usual and glidepath will be flown at a speed of 120 KIAS plus corrections.

(6) Shortly before the runway, with correct speed and attitude, retard the throttle to IDLE and, once over the runway gently "force" the aircraft to touch down not to fly long flares (fig. 7-28).

(7) In case of actual no-flap landing with the brake system operating, start braking cautiously as soon as the nosewheel touches the runway. If the braking system is inoperative, engage the steering, if available, to maintain directional control, use the emergency system as necessary and ask for barrier engagement.

Bear in mind that, since the landing speed is higher than usual, the ground run will be longer.

Considerations: from the didactical no-flap landing, you can either touch and go or go around.
If touchdown at minimum speed is desired, the aircraft remains on the flare for a longer time than usual and touchdown is in a more nose-high attitude.

i. Aided Landing (fig. 7-29)

This is a procedure permitting a given touch-down point to be reached in full safety.

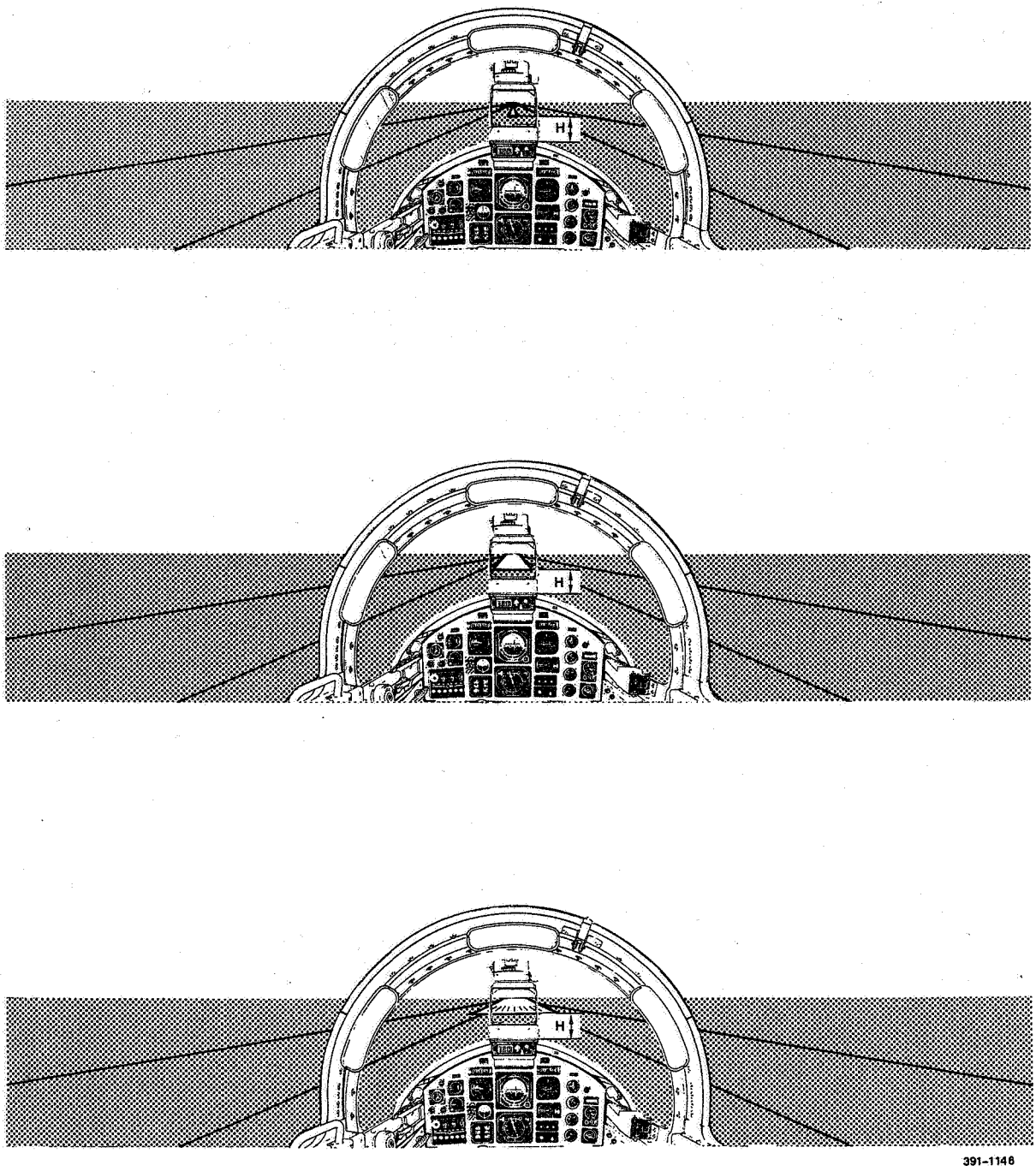


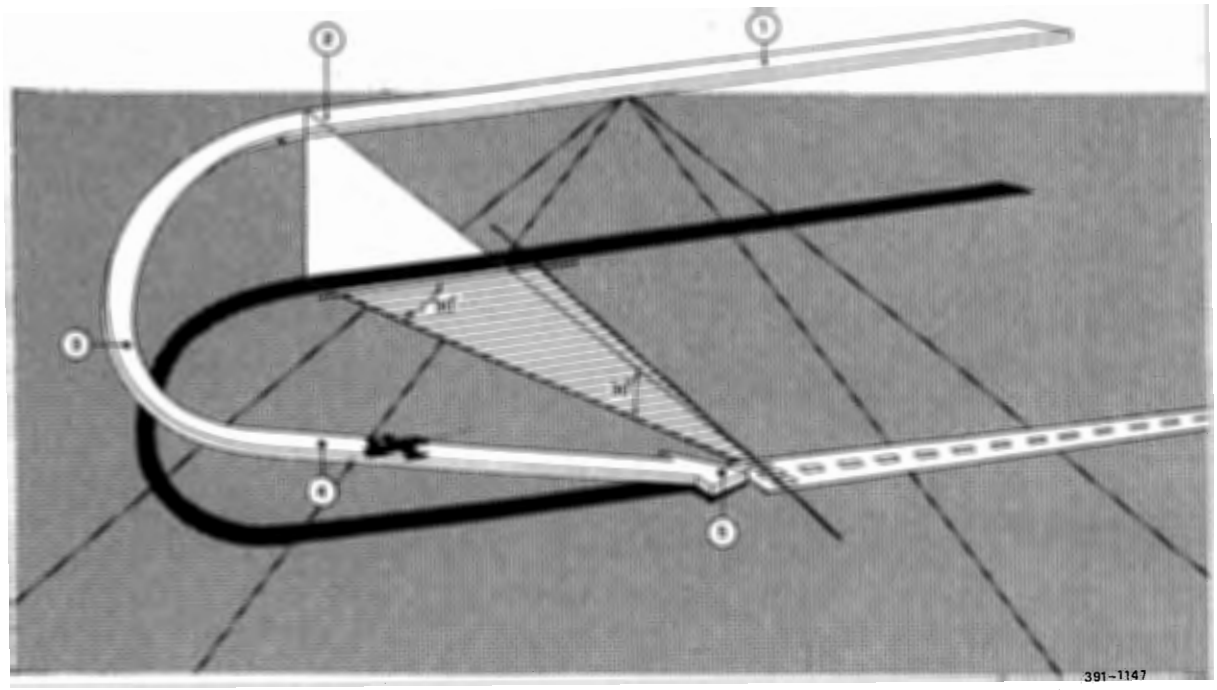
Figure 7-28. Attitude on Final - No-flap Approach

(1) The landing pattern is normal, exception made for the downwind leg which must be lengthened up to the position abeam of the initial point (30° aft).

(2) At the end of the downwind leg, set the flaps to "DN" and reduce power to 65% RPM; enter the base leg turn maintaining a speed of 120 KIAS plus corrections.

(3) At the end of the turn, which should be completed at an altitude not lower than 600 ft, the final will be shallower than usual because of the longer downwind leg, and necessarily flown with power on. In this phase, the airspeed to be maintained is 110 KIAS plus corrections.

(4) When positively over the runway and with a slight lead on the touchdown point, retard the throttle to IDLE and behave as for landing on a short runway.



1. 175 KIAS LANDING GEAR DOWN, RETRACT SPEEDBRAKE, FLAPS T/O, LANDING CHECK, AT 140 KIAS ADJUST RPM AT APPROX. 80%, AOA .45 TO .47
2. FLAPS DOWN, RPM APPROX. 65%, START DESCENT WITH AOA .40 i.e. 120 KIAS
3. SLOWLY REACH AOA .45, i.e. 115 KIAS, RPM APPROX. 60%
4. AGAIN CHECK LANDING GEAR DOWN AND LOCKED, TAXI LIGHT ON, MAINTAIN AOA .45
5. REDUCE RPM TO IDLE, LAND VISUALLY

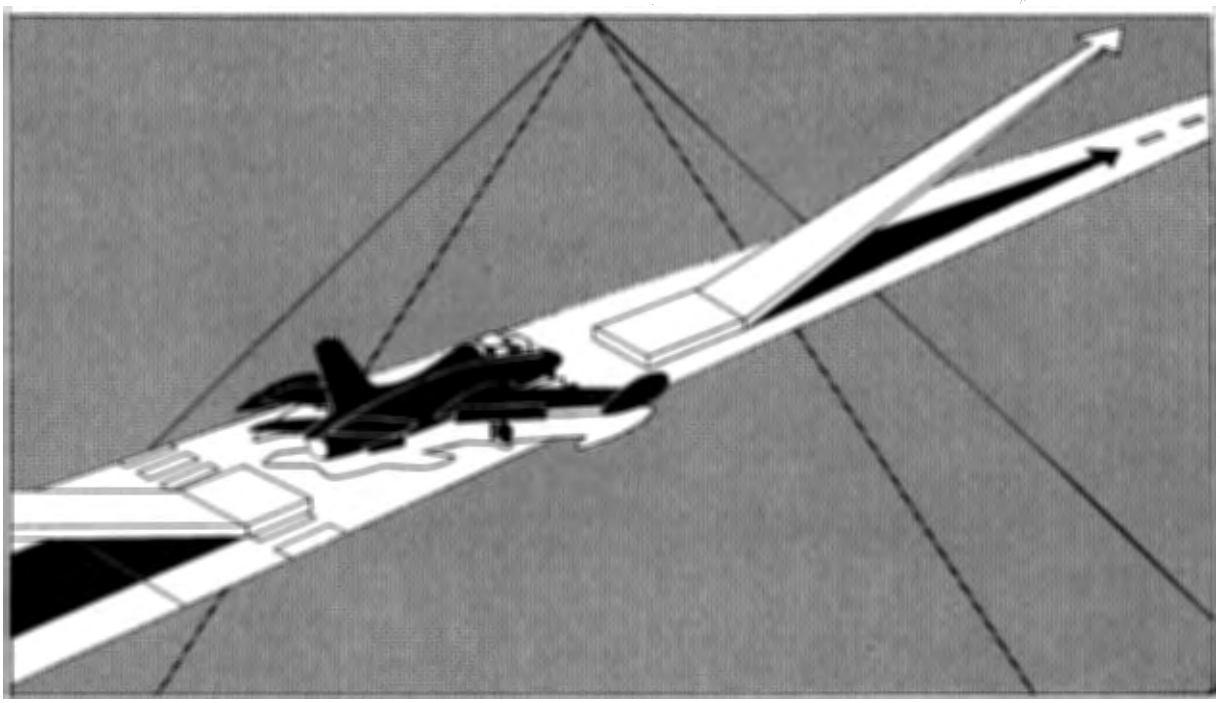
Figure 7-29. Aided Landing

Considerations: for training purposes and in dual flights only, an aided landing will be flown by referring to the AOA indicator. During this type of approach, once the base leg turn has been completed, bring the instrument pointer to the AOA value envisaged for landing, (AOA = 0.45°) by properly adjusting both power and attitude.
In clean configuration (D.I. equal to 0), and with a fuel load of 400 kg or less, this AOA value is attained at an airspeed of approx. 114 KIAS. If the AOA value tends to decrease, this means that the angle of attack is lower than envisaged and the approach speed is tendentially high: a small nose-up correction and a small power reduction will thus be necessary to maintain the glidepath. If the AOA value tends to increase, this means that the angle of attack is higher than envisaged and the approach speed is tendentially low: a slight nose-down correction and power increase will be necessary to maintain the glidepath.
In view of the vicinity of the aircraft to the ground, and of the low approach speed, it is essential that the glideslope be well visualized and attention well divided between the outside references and the instrument cross-check. Therefore, apply the correct "look outside" technique.

j. Practicing Touch-and-Go Landings (fig. 7-30)

This flight is still flown on the traffic pattern with the envisaged modalities and parameters. The only change is the touch-and-go phase.

(1) After landing, leave the flaps in the "DN" position, hold the nosewheel off the runway and increase engine speed to 100% RPM to prepare for take-off.



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HOLD THE NOSE WHEEL OFF THE RUNWAY; APPLY FULL POWER.
DO NOT FORCE THE AIRCRAFT INTO THE AIR, LANDING GEAR UP WHEN POSITIVELY AIRBORNE, FLAPS UP AT 120 KIAS

Figure 7-30. Touch and Go

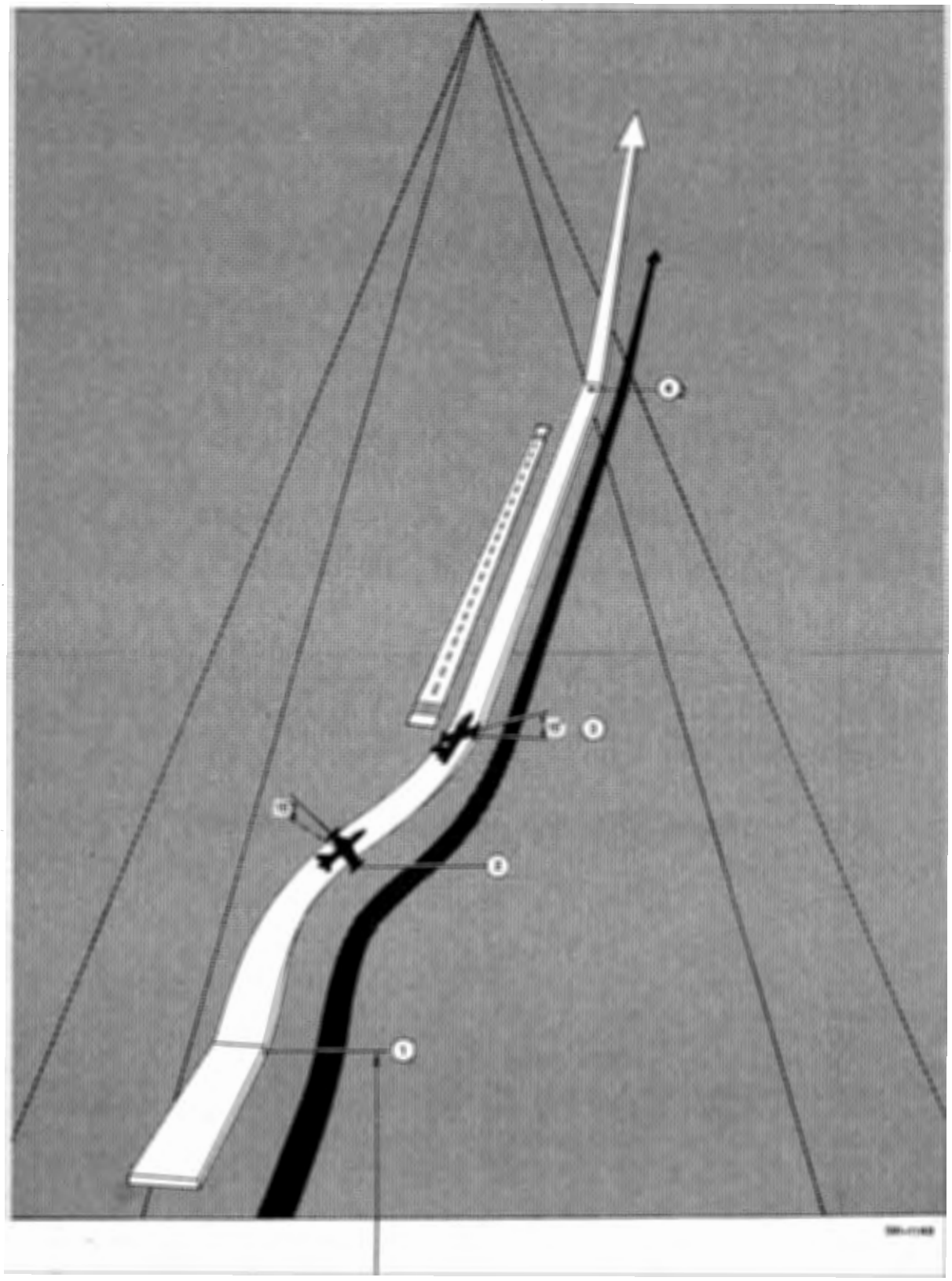
(2) After lift-off and at a safe altitude, carry out the prescribed checks taking care to retract the flaps at a speed not lower than 120 KIAS and not higher than 150 KIAS.
Remember that retraction of the flaps will cause a slight sinking of the aircraft that is to be counteracted with a slight variation of the aircraft nose-up attitude. It is recommended that flaps be retracted in two phases: first to T/O first and then to UP. Adjust the longitudinal trim that was set to nose-up for landing.

(3) Bear in mind that the take-off run will be shorter than usual and acceleration will be faster.

k. Go-Around (fig. 7-31 and 7-32)

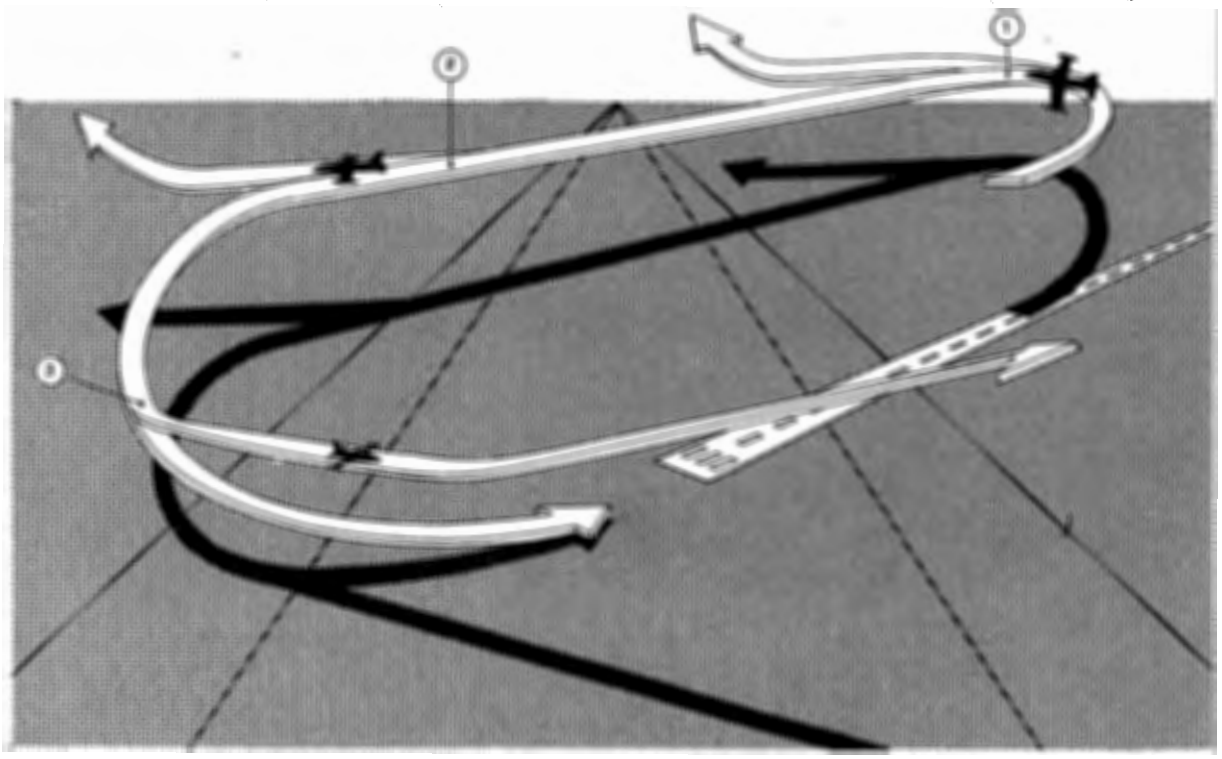
This is a procedure that is carried out at any point of the traffic pattern to clear the circuit. It can be carried out for training purposes or in case dangerous conditions should occur (traffic conflict). A go-around may be decided by the pilot in command (instructor or solo student pilot), or directed by the tower and/or by the mobile runway radio station.

(1) When a go-around is decided or directed: increase power to 100% RPM and concurrently, retract the speedbrake if out; with the engine positively accelerated, stop the altitude loss, retract the landing gear if out and, when airspeed is above 120 KIAS, raise the flaps to UP (if DOWN); avoid banking the aircraft while flaps go up. Carry out the post--take-off checks.



1. 100% RPM
2. BANK 15° EXTERNALLY TO PATTERN - LANDING GEAR UP
3. ALIGN A/C PARALLEL TO RUNWAY - AT 120 KIAS, FLAPS UP - AFTER TAKE OFF CHECKS
4. AT END OF RUNWAY START A NORMAL CLIMB

Figure 7-31. Go-around



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1. SPEEDBRAKE IN, 100% RPM, LEVEL WINGS OFF, LEAVE LANDING PATTERN IN CLIMBING FLIGHT
2. 100% RPM, SPEEDBRAKE, LANDING GEAR AND FLAPS UP, BANK 30°, TURNING 45° OUT, LEAVE LANDING PATTERN IN CLIMBING FLIGHT
3. LEVEL WINGS OFF, 100% RPM, SPEEDBRAKE, LANDING GEAR AND FLAPS RETRACTED, HOLD ALTITUDE UNTIL YOU LEAVE THE CIRCUIT, THEN, WHEN POSITIVELY OUT OF CIRCUIT, START CLIMBING

Figure 7-32. Go-around in Landing Pattern

(2) During training, if this maneuver is flown on final, after the post-take-off checks have been performed, accomplish a 15° banked turn in the direction opposite to the pattern to realign the aircraft parallel to the runway to easily clear the traffic. Then take up a normal acceleration attitude having care to reach the departure end of the runway at an altitude at least 700 ft lower than the pattern altitude, at an indicated airspeed not higher than 250 KIAS if intention is to leave the patterns or to stay in the pattern. If the intention is to attain and hold the pattern, decrease power to approx. 82% RPM at the required lead point (see level-off from climb).

(3) If a go-around is to be done at an altitude lower than 300 ft for dual flights, and 500 ft for solo flights, the procedure will be the same as detailed above except for the turns (which will not be made), and for the approach direction that must be maintained.

(4) Bear in mind that when the pilot decides to make a go-around, he must contact the tower as prescribed.

(5) If a go-around must be performed at any point of the landing pattern to clear the pattern, strictly comply with the traffic regulations of the airport.

Figures 7-30 and 7-31 show some types of go-arounds referring to the most significant points of the landing pattern.

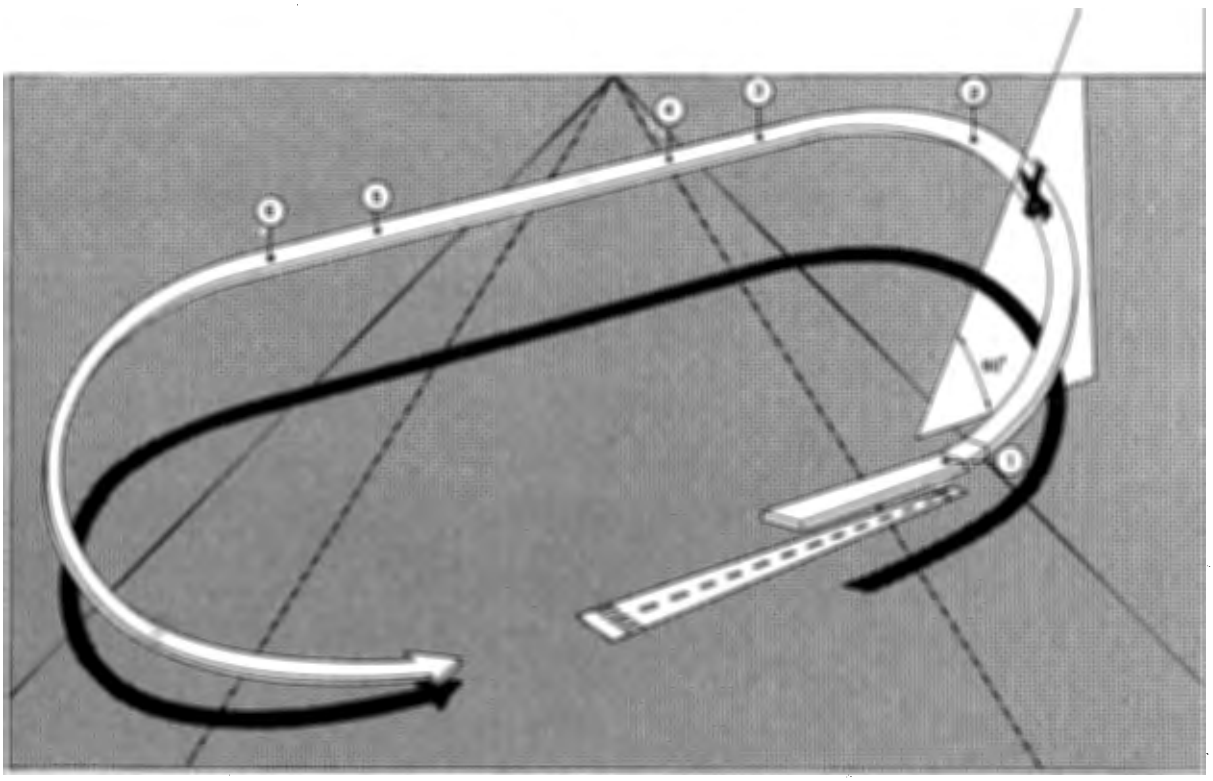
I. Closed Traffic (fig. 7-33)

This is a type of circuit that permits an aircraft which must interrupt final approach or must accomplish a touch-and-go landing to come back to landing with the minimum amount of fuel and in the shortest possible time. A closed traffic is flown for training purposes prior clearance from the tower or, in real circumstances, under special emergency conditions.

(1) Accomplish a go-around or touch-and-go landing according to the detailed procedure, attain the runway end with 100% RPM and a minimum airspeed of 170 KIAS, pitch up slightly and bank the aircraft 60° while maintaining the same speed as used at the beginning of the maneuver.

(2) Using a variable lead point, as a function of the maneuver rate of climb and indicator airspeed, reduce power to approx. 65% RPM, aligning the aircraft parallel to the runway in the downwind leg and informing the tower of the attained position. The landing gear is to be lowered when abeam of the contact point. After carrying out the prescribed checks, perform a tendentially aided landing procedure to ensure that landing is successful.

A training closed traffic may be accomplished also from a touch and go landing: the aforementioned procedure remains applicable. In case of an actual need to fly a closed traffic, among the mentioned procedure conditions, the only one that remains applicable is the condition calling for an airspeed equal to or higher than 180 Kts.



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1. RPM - FULL; AT END OF RUNWAY WITH 170 KIAS
2. RPM 65%
3. 1500 ft QNH
4. CALL "DOWNWIND FROM CLOSED" AND "FUEL LEVEL LOW" IF REQUIRED
5. ABEAM OF TOUCHDOWN POINT 175 KIAS, LANDING GEAR DOWN, SPEEDBRAKE IN
6. 140 KIAS: FLAPS DOWN, THEN NORMAL FINAL

Figure 7-33. Closed Traffic

When accomplishing a closed pattern from a go-around, the conditions to start the maneuver are as follows: 100% RPM; tower clearance; attain the runway end at the prescribed altitude (see go-around), nose-up attitude. During the closed traffic maneuver, start reducing power as a function of the IAS attained at the end of the runway.

m. Straight-in Approach (fig. 7-34)

To cope for intense traffic, some airports require that a long straight--in approach be flown: for this approach, the aircraft will be correctly positioned either by use of the visual references or by radar vectors. This procedure will be similar to the procedure adopted in case of radar-aided approach, namely:

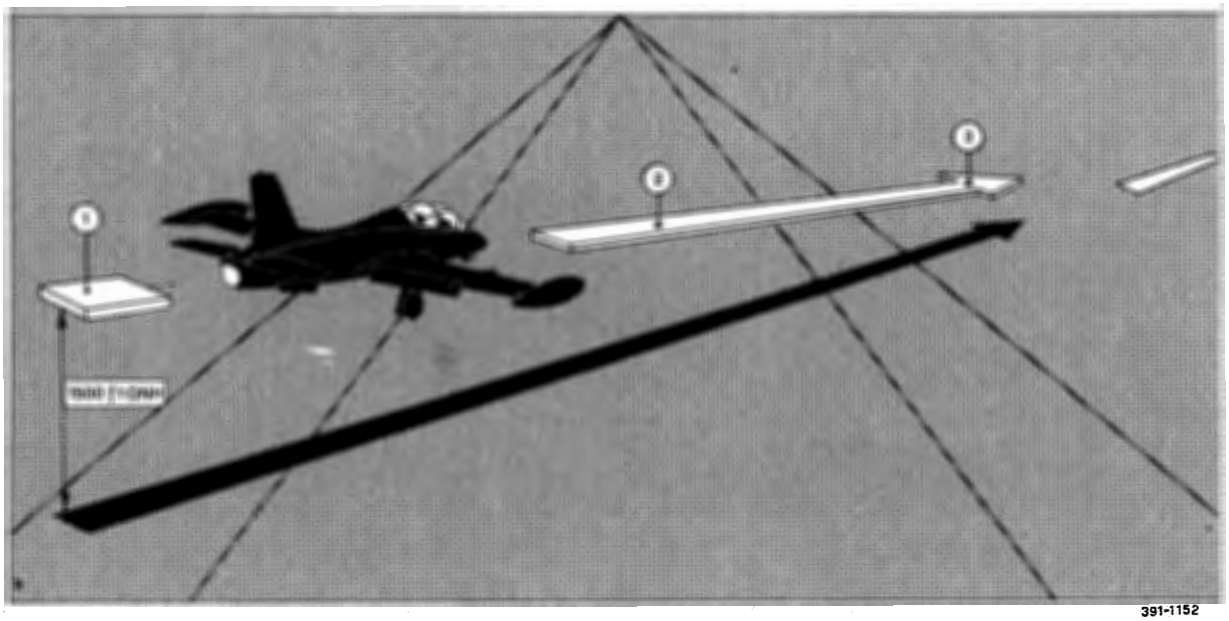
(1) After completion of the pre-descent checks and the pattern entry checks, set up the approach (at normal pattern altitude) 3 to 4 NM from the runway threshold, aligned with the runway and with a IAS suitable for the performance of the before landing checks.

(2) Contact the tower notifying the intention to fly a straight-in approach, by saying, for instance: "Jumbo TWR, Lion 82, straight-in approach". The tower will reply as a function of the existing traffic conditions.

(3) When clearance from the tower is obtained and before landing checks completed, start the descent at 130 KIAS with T/O flaps. The glideslope will be visualized by reference to an optical approach systems (VASIS) or radio-electrical systems (RADAR-G.C.A). At approx. 3 to 4 NM from the runway threshold, set the flaps to DOWN and adjust power so as to reach the runway end at 115 KIAS for a normal landing (AOA = 0.45).

n. Forced Landing

See Chapter XIV, paragraph 2.p. "Emergencies and Simulated Emergencies".



1. AT 4 NM FROM END OF RUNWAY: ALIGNED, 170 KIAS, LANDING GEAR DOWN, SPEEDBRAKE IN, FLAPS T/O, LANDING GEAR CHECK
2. 75% RPM, 130 KIAS, CALL FOR STRAIGHT-IN APPROACH
3. ~60% RPM, FLAPS DOWN, 115 KIAS

Figure 7-34. Straight-in Approach Landing

PART TWO - CHAPTER VIII

AEROBATICS

TABLE OF CONTENTS

Title	Page
General	8-1
Coordination Maneuvers	8-2
Unusual or Extreme Attitudes	8-8
Aileron Roll	8-11
Loop	8-12
Barrel Roll	8-15
Split "S"	8-17
Immelmann (Roll off the Top)	8-18
Cuban Eight	8-19
Cloverleaf	8-20
Spin	8-22
Composite Aerobatics	8-26
Maneuvrability and Aerobatics at High Altitude	8-27
Other Aerobatics	8-30
Loop with Non-Standard Parameters	8-33

1. GENERAL

Aerobatics are coordinated flight maneuvers which are always kept under control by the pilot and cause strong variations of pitch and roll attitudes, airspeed and altitude.
The purpose of aerobatics is to help the pilot develop confidence, sensitive feel and coordination and to make almost automatical the reactions and corrective actions required to pass from any position in the space to another one, in the most rational and simplest way.
Aerobatics thus become the basis for the performance of all attack and defensive maneuvers envisaged in the operational role and give the confidence in the ability to fly the aircraft which allows the pilot to fully devote to combat, piloting in all attitudes having turned into an instinct.
From the above definition of AEROBATICS it is evident that also unusual attitudes, spin and coordination maneuvers are to be considered as aerobatic maneuvers.

a. Pre-aerobatics and Post-aerobatics Checks

Before performing any aerobatic maneuver, it is necessary that the pilot accomplishes some checks:

- checks of the space where he will perform the maneuver
- checks of the aircraft (inside and out)

The student pilot should learn the following list of checks by heart and accomplish them rapidly, but scrupolously:

(1) Pre-aerobatics Checks

(a) Altitude and position
(b) Fuel
(c) TACAN, VOR, ILS, RNAV: NOT SLAVED
(d) FLT DIR: STBY
(e) Landing gear, speedbrake, wing flaps: UP and OK
(f) Harness tightened, shoulders restrained
(g) Engine instruments: OK
(h) NO loose objects in the cabin

(2) Post-aerobatics Checks

(a) Landing gear, speedbrake, wing flaps: UP and OK
(b) HSI consistent with standby compass
(c) ADI consistent with STBY attitude indicator
(d) Engine instruments: OK within the limits
(e) Fuel
(f) Position, altitude

It will be necessary to accomplish the above checks in a loud voice, in full and not just saying a simple OK.
For example, the engine instrument check will be:
"Engine 96%, 715°, 20, 2 bar, 225 kilos" that means: RPM 96%, jet pipe temperature 715°, flowmeter 20 kg/min, oil pressure 2 bar, remaining fuel 225 kg.

2. COORDINATION MANEUVERS

The coordination maneuvers are those maneuvers performed to allow the pilot to clearly identify the aircraft attitudes with respect to external references, to develop "pitch attitude, roll attitude, airspeed" coordination, and to refine the sensitive feel in controlling the aircraft when speed rapidly changes.

a. Wingover

This is a coordination maneuver through which an aircraft changes its heading by 180° flying a trajectory continuously and progressively changing with respect to the three basic reference axes (fig. 8-1 and 8-2). The pilot shall visualize and fly a parabolic track above the horizon. The wingover consists of wide and continuous variations of pitch attitude, roll attitude, direction of motion, airspeed and altitude.
The purpose of the maneuver, in the initial phase of flight training, is:

(1) To familiarize the pilot with wide attitude and airspeed variations by teaching him to identify the subsequent positions reached by the aircraft with respect to pre-set external reference points;

(2) To train the pilot in the coordination on the attitudes as a function of "targets" to be reached (attainment of specific airspeeds, headings, altitudes, etc.);

(3) To allow the pilot to develop the desired confidence in visual flight: it derives from the familiarity with the aircraft characteristics, and from knowing that he can fully exploit them.

(4) To clear the surrounding space, to prepare to a specific aerobatic maneuver, to fly in formation and trail.

- After the pre-aerobatics checks, select a section line that is easily identifiable on the ground (road, coast line, etc.) and a point on the horizon at 90° with respect to the direction of the beginning of the maneuver, on the side selected for the maneuver.
With power at 87%, place the aircraft parallel to the selected reference line and attain a speed of 260 KIAS, if necessary, by lowering the aircraft nose.

- Apply the controls gradually with the required lead, as a function of the possible initial nose down attitude, in order to cross the horizon at the selected speed and with a slow pitch variation. Gradually

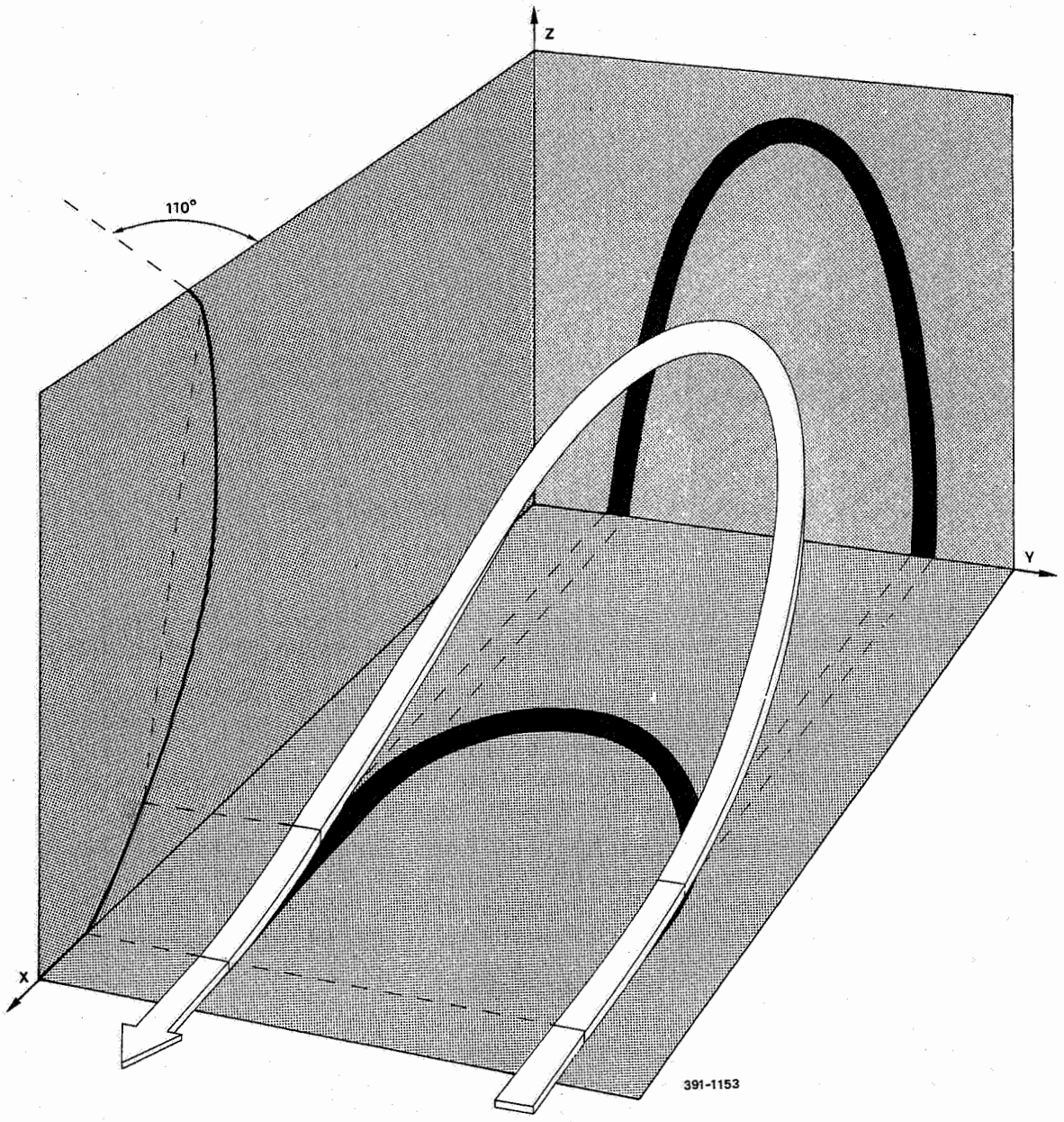
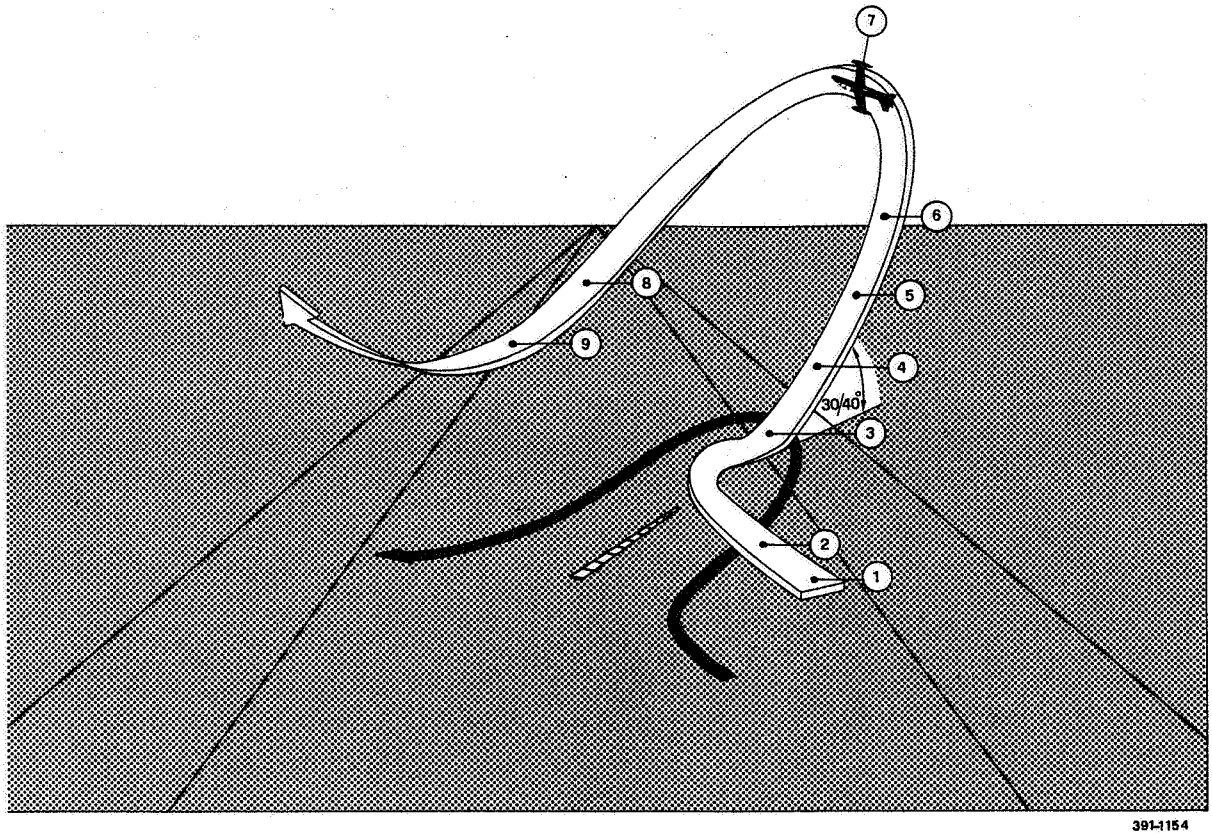


Figure 8-1. Wing Over



1. PRE-ACROBATICS CHECKS, TRIM
2. 87% RPM
3. FLY PARALLEL TO REFERENCE, 260 KIAS
4. CLIMB WITH WINGS LEVEL, 30°/40° AND APPROX. 240 KIAS
5. 220 KIAS; APPROX. 30° BANK
6. 60° OF BANK; APPROX. 170 KIAS
7. 110° OF BANK; APPROX. 100 KIAS OVER THE TOP
8. WINGS LEVEL
9. 260 KIAS

Figure 8-2. Wing Over (Performance)

apply back pressure on the stick and, always keeping the wings level, enter a 30° to 40° pullup (as a function of the maneuver initial speed).

- At this point act on the stick gradually and smoothly to start changing the roll attitude with a moderate rate of roll, to reach 90° to 110° of bank and 100 KIAS over the top.
Apply the convenient pressure on the stick and act in a coordinate way in order to cross the horizon on the selected reference point.

- If the recommended technique has been correctly enforced, the aircraft will take a maximum nose up attitude of 70° to 80° after approx. 70° of turn, the airspeed over the top will be 90 to 100 KIAS and the nose will cross the horizon in proximity of the reference point at 90°.

CAUTION

When over the top of the maneuver, avoid abrupt actions on the controls that could lead to buffet or even to stall.

- The dive phase is symmetrical to the climb phase. At the beginning, it is necessary to continuously act on the stick to allow the aircraft to decidedly start the nose down.

Subsequently, action should be taken simultaneously on pitch and roll attitudes to complete "wing levelling" and "pull up" on the initially selected straight reference, at the desired airspeed.

- When the maneuver is performed for training-evaluation purposes, the rate of roll for entry and recovery should be the same (within the already specified range of values).

- When the maneuver is not performed for training-evaluation purposes, the parameters are at pilot's discretion, though remaining related to each other.

- Throughout the maneuver, the aircraft must be submitted to positive accelerations and the use of controls must be constantly smooth, gradual, continuous and coordinated.

- It is an error to change the pitch and roll attitudes separately, viz. without coordination.
"To pull" rather than "to bank" should be the first consideration. Remember to visualize a parabolic path on the horizon and act so that the aircraft nose follows it precisely. Any error (of attitude or parameters), noted in the initial maneuvers, will have to be subsequently corrected by modifying the previously flown parabolic path (higher parabola, lower parabola, etc.).

b. Lazy Eight (fig. 8-3)

This is a maneuver of attitudes-airspeed coordination consisting of a sequence of 180° climbing and descending turns to the right and to the left, requiring a particular attention to coordinate bank as a function of the rate of turn.
The pilot must visualize an arc above the horizon and describe it with the aircraft (at least two times and in opposite directions).

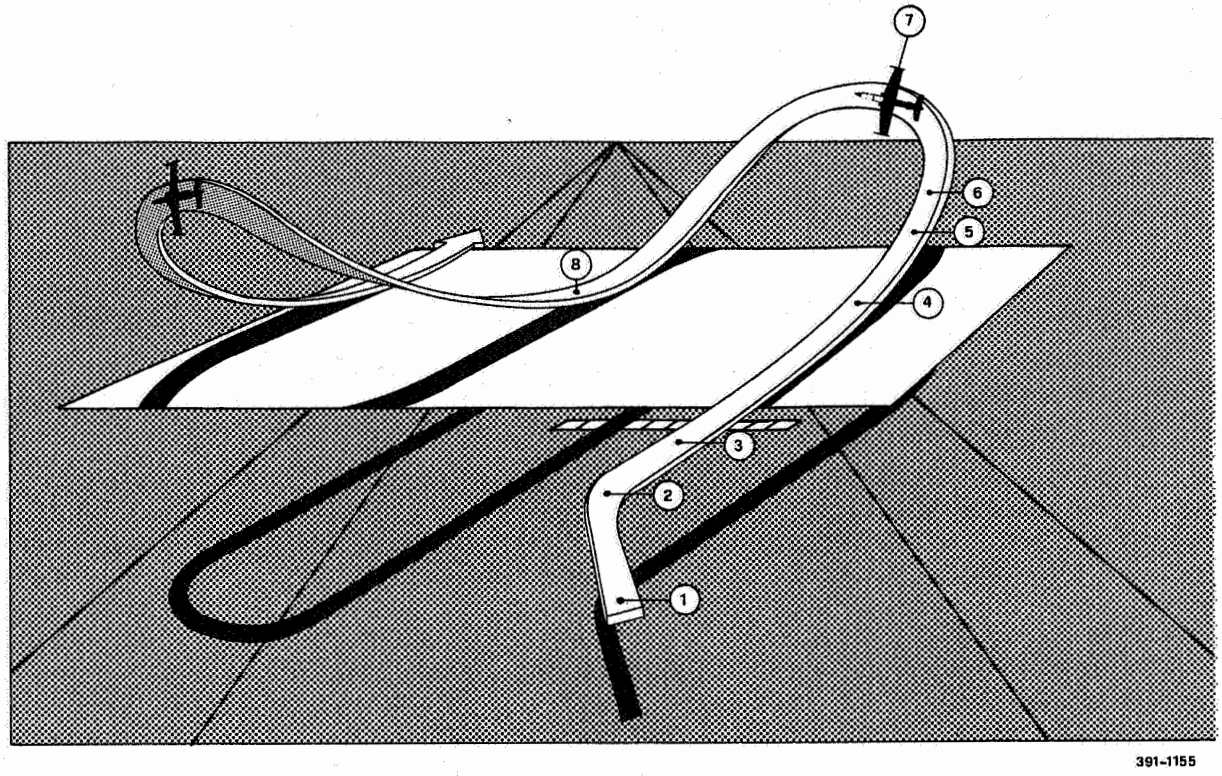
(1) Set power to 85%, select a straight section line (road, coast line, etc.) and a point at 90° above the horizon. Fly the aircraft parallel to the selected section line and lower the nose to reach an airspeed of 250 KIAS.

(2) Always start the maneuver on the horizon, and with the aircraft in straight and level flight. The maneuver will develop in 180° turns describing two or more arcs above the horizon.

(3) With wings level and nose on the horizon, start a climbing turn in the desired direction. Try to fly the maneuveur continuously increasing, degree after degree, the pitch attitude, roll attitude and the rate of turn: in this way the 45° maximum pitch attitude will be attained at approx. 45° of turn with 45° of bank.
From this point on, while the aircraft bank angle and the rate of turn increase by the same amount until 90° of bank and 90° of turn are reached, the nose up angle above the horizon progressively decreases. We will therefore have:

- 60° of turn with 60° of bank and nose 30° above the horizon
- 75° of turn with 75° of bank and nose 15° above the horizon
- 90° of turn with 90° of bank and nose on the horizon

In the first phase, it is a common error to change the pitch attitude very slowly while banking the aircraft too much: the attainment of a fairly flat pitch attitude and of a bank angle higher than 45° in the first 45° of turn, results in a too high airspeed close to the top. In the first phase it is therefore necessary to pull up rather than to bank.



1. TRIM, PRE-ACROBATICS CHECKS ARE NOT REQUIRED
2. FLY NORMALLY TO REFERENCE
3. 86% RPM
4. 250 KIAS, WINGS LEVEL CLIMB AND TURN, 1° BANK, 1° TURN
5. 45°/45°/45°
6. 60°/60°/30°
7. 90° OVER THE TOP AND 130 KIAS
8. 250 KIAS AT LOW POINT AND NORMAL TO REFERENCE

Figure 8-3. Lazy Eight

The speed must progressively decrease to have:

- approximately 190 KIAS after 60° of turn
- 130 KIAS after 90° of turn, and again increase to:
- 170 KIAS after 120° of turn
- 250 KIAS after 180° of turn, and so on.

(4) Over the top, the aircraft nose should start back down and describe an arc (beginning above the horizon) symmetrical to the previous arc; the pilot should bear in mind that pitch and roll attitudes must continuously change; the maximum nose down attitude will be attained after 135° of turn with 45° of bank (and 45° dive).

(5) To bring the nose back on the horizon with wings level, play the progressive and smooth maneuver accomplished during the first phase (climbing), to reach a speed of 250 KIAS after 180° of turn.

(6) In the descent phase, avoid both keeping the nose too high and reducing the bank with an excessive lead: otherwise, the trajectory will flatten and the maneuver will be completed before 180°, at low speed.

(7) Immediately start another evolution identical to the previous one, adopting the same procedure, but turning in the opposite direction: there shall be no pause between the mentioned phases as far as reversal of pitch and roll attitudes is concerned.

- The lazy eight must be performed so as to constantly change attitudes and describe contiguous and continuous semi-circles.

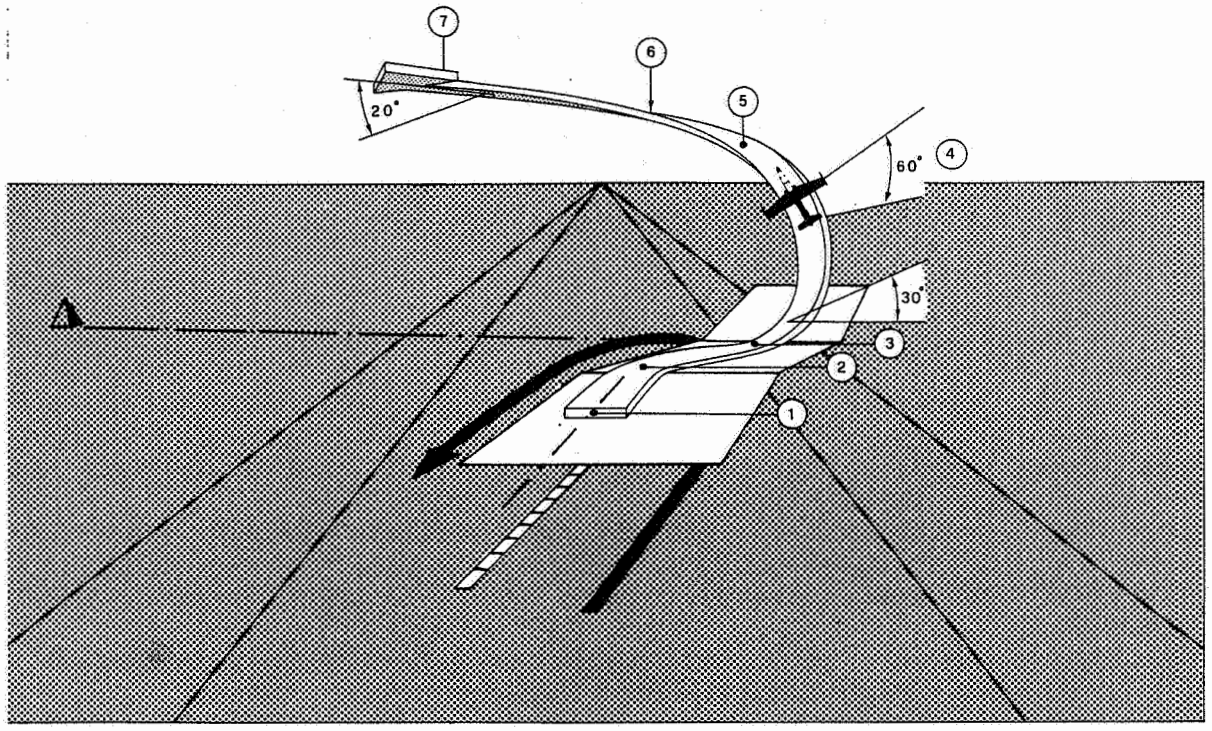
- All anomalies found in the maneuver, both of airspeed and attitudes, must be corrected by referring to the trajectory visualized at the beginning of the maneuver.

c. Chandelle (Climbing Turn) (fig. 8-4)

This is a coordination maneuver during which the aircraft performs a 180° turn continuously varying heading and roll attitude. The pilot must fly a constant, approx. 20° nose-up attitude by referring to the ADI and to a very far reference point located at 90° on the side of initial direction of the maneuver.
The maneuver is intended to train the pilot to visualize the aircraft attitude with respect to preset reference points and to develop coordination when using controls during attitude, heading, altitude and airspeed changes.

(1) After pre-aerobatics checks, set power to 85%, select a section line (road, coast line, etc.) and a point at 90° on the horizon, on the side selected for the maneuver. Bring the aircraft parallel to the selected reference line.

(2) Start the maneuver with an attitude of approx. 30° below the horizon and wings level. Do not start the maneuver with the nose on the ho-



1. FLY PARALLEL TO A REFERENCE LINE; RPM 85%
2. START A 10° DIVE SELECT A FAR REFERENCE POINT AT 90°
3. AT 265 KIAS BEGIN A CLIMBING TURN, BRING THE NOSE ACROSS THE HORIZON AT 270 KIAS; 30° OF BANK AND 30° OF TURN PITCH ALTITUDE 20°
4. 60° OF BANK AND 90° OF TURN, PITCH ATTITUDE CONSTANT 20°
5. START DECREASING BANK, PITCH ATTITUDE CONSTANT 20°
6. AFTER 150° OF TURN: 30° OF BANK
7. OVER THE TOP, FLY PARALLEL TO REFERENCE, 130 KIAS AND 20° PITCH ATTITUDE. RECOVER BY ROLLING THE A/C IN THE DIRECTION OPPOSITE TO ENTRY

Figure 8-4. Chandelle

rizon: in this case the applicable parameters could not be adhered to, and the maneuver would at any rate be incorrect.

(3) At 265 KIAS (i.e. with a lead of 5 kt with respect to the prescribed entry speed of 270 KIAS), apply a slight back pressure on the stick and roll the aircraft to start a coordinated climbing turn. The aircraft nose must cross the horizon after 30° of turn, with a 30° of bank and 270 KIAS.
At the beginning of the maneuver, the aircraft should be allowed to align in pitch on the horizon.

(4) Continue changing attitudes so as to gradually attain 60° of bank at the 90° reference point. At the same time, change the pitch attitude constantly and smoothly until the mentioned 20° nose-up attitude is attained and maintained.

(5) After 90° of turn, flown with the aforementioned attitudes, start reducing wing bank gradually, taking care to apply an adequate back pressure on the stick to initially make up for the lift loss due to the reduction of speed.
Subsequently, in the final part of the chandelle, it will be conversely advisable to relax the pressure on the controls to avoid that the progressive reduction of the angle of bank brings the aircraft to excessively nose-up attitudes. Complete the maneuver after 180° of turn, with wings level, a nose-up attitude of approx. 20°, and a speed of 130 KIAS. The chandelle is now considered complete, thus proceed to rollout by rolling the aircraft to the opposite side, and allow the nose to drop below the horizon.

- It is pointed out that if the initial pullup has been performed too quickly, it is best to interrupt the maneuver to avoid reaching extreme or critical attitudes at its end.

3. UNUSUAL OR EXTREME ATTITUDES

a. General

The unusual climbing or diving attitudes are attained due to piloting errors.
When flying aerobatics, especially if over the top maneuvers, the aircraft may came to a condition not envisaged by the maneuver, in which speed is very high and increasing and nose low, or speed is very low and decreasing and nose very high.
Under these circumstances, continuing the maneuver clearly brings the aircraft out of the specified safety parameters; it is thus necessary to INTERRUPT the maneuver without hesitation and restore the line of flight conditions.
The recovery procedures are essentially two and must be performed correctly to obtain "safety" and minimum loss of altitude.

b. Recovery from Unusual Nose Low Attitude (fig. 8-5)

The unusual attitude is recognized by the pilot from the considerable loss of altitude rather than from the marked dive (more or less banked) and, mainly, from the rapid and abnormal increase of speed that is not envisaged in the normal maneuver development.

- For recovery: move the throttle to IDLE and LEVEL the wings through the shortest side. Then apply a back pressure on the stick to bring the aircraft back to the line of flight. If the speed is above, or is expected to be above 250 KIAS, lower the speedbrake.

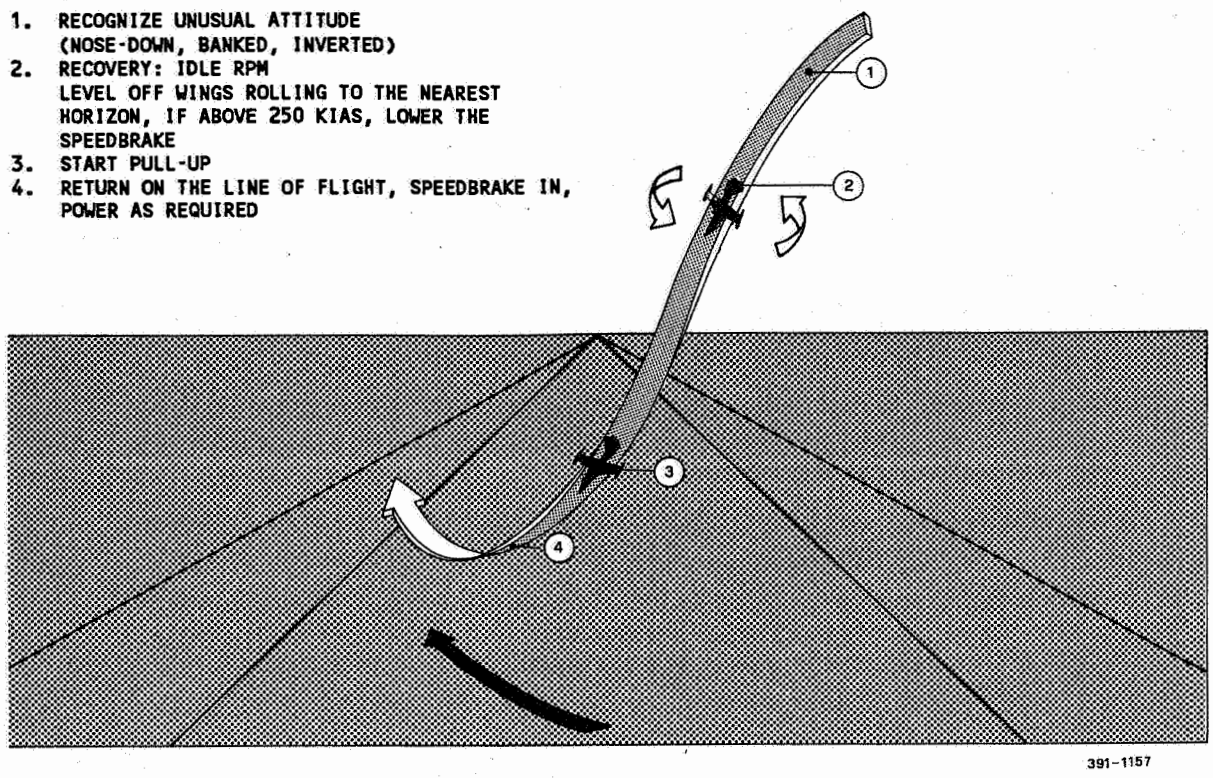

1. RECOGNIZE UNUSUAL ATTITUDE (NOSE-DOWN, BANKED, INVERTED)
2. RECOVERY: IDLE RPM LEVEL OFF WINGS ROLLING TO THE NEAREST HORIZON, IF ABOVE 250 KIAS, LOWER THE SPEEDBRAKE
3. START PULL-UP
4. RETURN ON THE LINE OF FLIGHT, SPEEDBRAKE IN, POWER AS REQUIRED
1
2
3
4
391-1157

Figure 8-5. Recovery from Unusual Nose - Low Attitude

- With the aircraft on the line of flight, restore cruise RPM and retract the speedbrake, if down, when cruise speed is restored.

- To bring the aircraft on the line of flight when it is inverted, first roll towards the wing level attitude (aircraft right side up), then pull up.

CAUTION

If the recovery from steep diving attitude is performed at high altitude, it will be necessary to extend the speedbrake 30 knots before the limit Mach number, even if the airspeed indicator reads a low airspeed.

c. Recovery from Unusual Nose High Attitude (fig. 8-6)

The unusual attitude is recognized by the pilot from the rapid increase of altitude (rather than from the excessive nose up attitude (more or less banked) and, mainly, from the abrupt and abnormal loss of speed, not envisaged in the normal maneuver development.

- For recovery: quickly apply full power (100% RPM), make sure the speedbrake is up and bank the aircraft on the side of the lower wing. Just above 90°, apply a slight back pressure on the stick to lower the nose a little below the horizon. With increasing speed and beyond 120 KIAS, level the wings by rolling the aircraft through the shortest side. Then, return the aircraft to the line of flight and restore the cruise parameters.
Only when the cruise speed is attained, reduce power to the envisaged correct setting.

- It is pointed out that during recovery from nose high attitude, the steeper is the climb attitude (or the lower and more rapidly decreasing is the speed), the ampler is the required angle of bank.

In extreme cases, it will be necessary to nearly invert the aircraft to facilitate nose lowering as much as possible.

NOTE

- Pre-aerobatics checks must be accomplished before performing the maneuvers for training purposes.
- Recoveries from vertical attitudes will be particularly useful as an introduction to aerobatics, and especially to over the top maneuvers.
- Recovery is considered completed when the cruise parameters are restored.
- During recovery from the two unusual attitudes, the way in which flight controls are used is quite different: they must be used resolutely with nose low and smoothly with nose high.

CAUTION

Under all circumstances, but in particular at high altitude and low speed, do not advance throttle too quickly to avoid compressor stall. Conversely, power can be always reduced resolutely (though never too much).

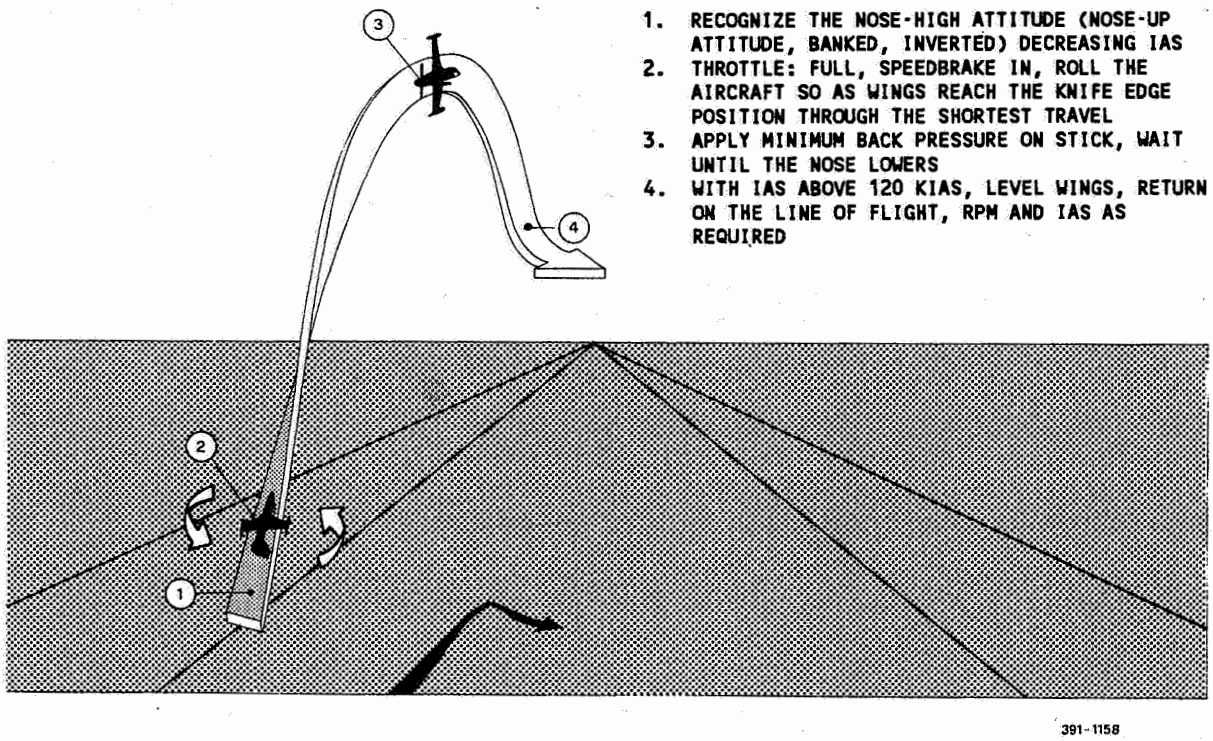

3
4
2
1
1. RECOGNIZE THE NOSE-HIGH ATTITUDE (NOSE-UP ATTITUDE, BANKED, INVERTED) DECREASING IAS
2. THROTTLE: FULL, SPEEDBRAKE IN, ROLL THE AIRCRAFT SO AS WINGS REACH THE KNIFE EDGE POSITION THROUGH THE SHORTEST TRAVEL
3. APPLY MINIMUM BACK PRESSURE ON STICK, WAIT UNTIL THE NOSE LOWERS
4. WITH IAS ABOVE 120 KIAS, LEVEL WINGS, RETURN ON THE LINE OF FLIGHT, RPM AND IAS AS REQUIRED
391-1158

Figure 8-6. Recovery from Unusual Nose - High Attitude

4. AILERON ROLL (fig. 8-7)

This is an aerobatic maneuver during which the aircraft performs a full roll around an axis parallel and very close to its longitudinal axis.
The control surface that allows the maneuver to be performed is the aileron: the rudder and elevator serve to keep direction and restore the aircraft normal flight attitude.

- After accomplishing the pre-aerobatics checks, perform a clearing turn with 87% RPM and select a far reference point on the horizon and a straight reference line on the side of the aircraft.
Dive to 20° below the horizon.

- The maneuver initial speed must be comprised between 250 and 300 KIAS.

- For training: 87% RPM - Cross the horizon at 270 KIAS.

- Pull up the aircraft up to approx. 20° to 30° on the horizon, neutralize the stick smoothly so as not to perceive that pitch attitude variation stops.

- Move the stick laterally toward the side of the desired roll. As a result of aileron deflection, the aircraft will start rolling around the longitudinal axis.

- When approaching the inverted phase, increase lateral pressure on the stick to keep rolling constant. In this phase, if the aircraft nose tends to drop below the horizon (low rolling speed) it will be necessary to slightly push the stick forward to hold the nose up. In the last 90° of roll, if the aircraft nose still tends to drop below the horizon, blend in some rudder pressure on the side of roll.
At the end of the maneuver, the controls must be at center: it is therefore necessary to move them to the center with a lead to avoid abrupt movements leading to a sudden stopping of aircraft roll.
Start bringing the controls back to the center position in the last 45°

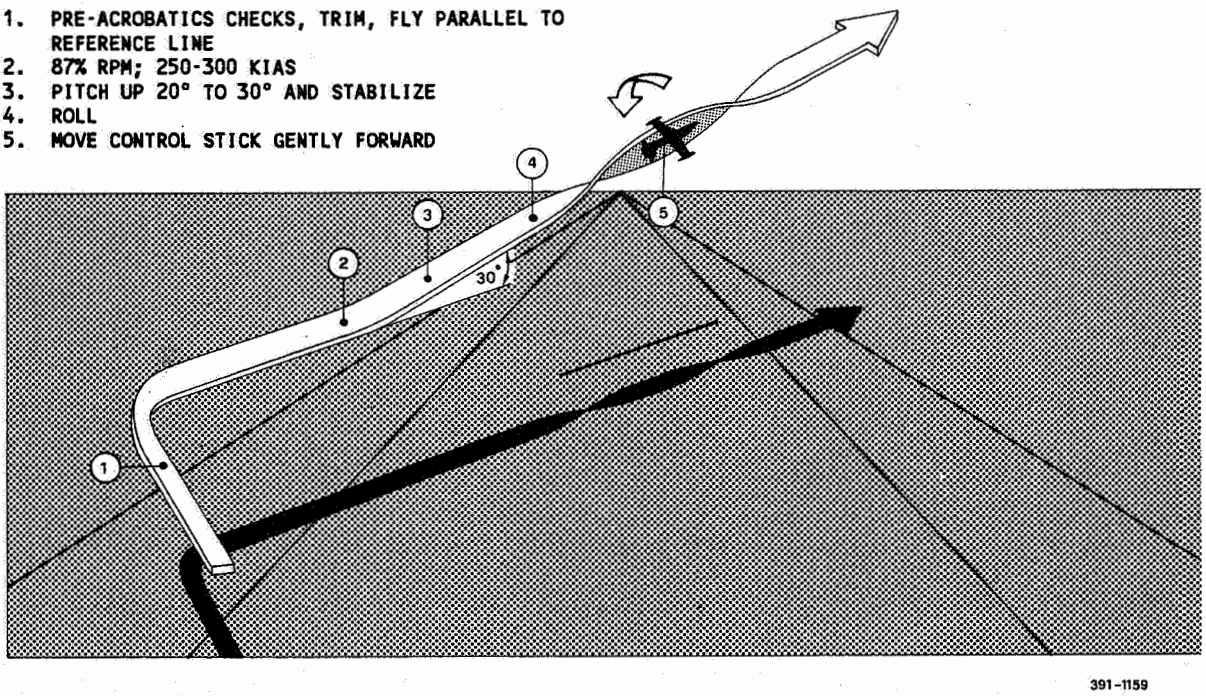


Figure 8-7. Aileron Roll

of roll to ensure that the maneuver is complete when the wings level attitude is attained (if necessary, act with coordination on the rudder pedals).

- It is to be noted that, under the same conditions of IAS, the rolling speed depends on the lateral displacement of the stick; the rapidity at which the stick is moved affects only the entry speed.

5. LOOP (fig. 8-8)

It is a maneuver during which the aircraft performs an almost circular trajectory in the vertical plane and a rotation around its pitch axis.

NOTE

The trajectory really consists of two successive half spiral coils, one up and one down.

The combination of these two motions generates the maneuver called LOOP. If the same load factor (g) were always applied, the reduction of speed would "reduce" the loop radius according to the formula $R = \frac{V^2}{a}$ where

R = loop radius, V = true airspeed, a = centripetal acceleration.
In the descending phase of the loop, the increasing speed would conversely increase the loop radius.

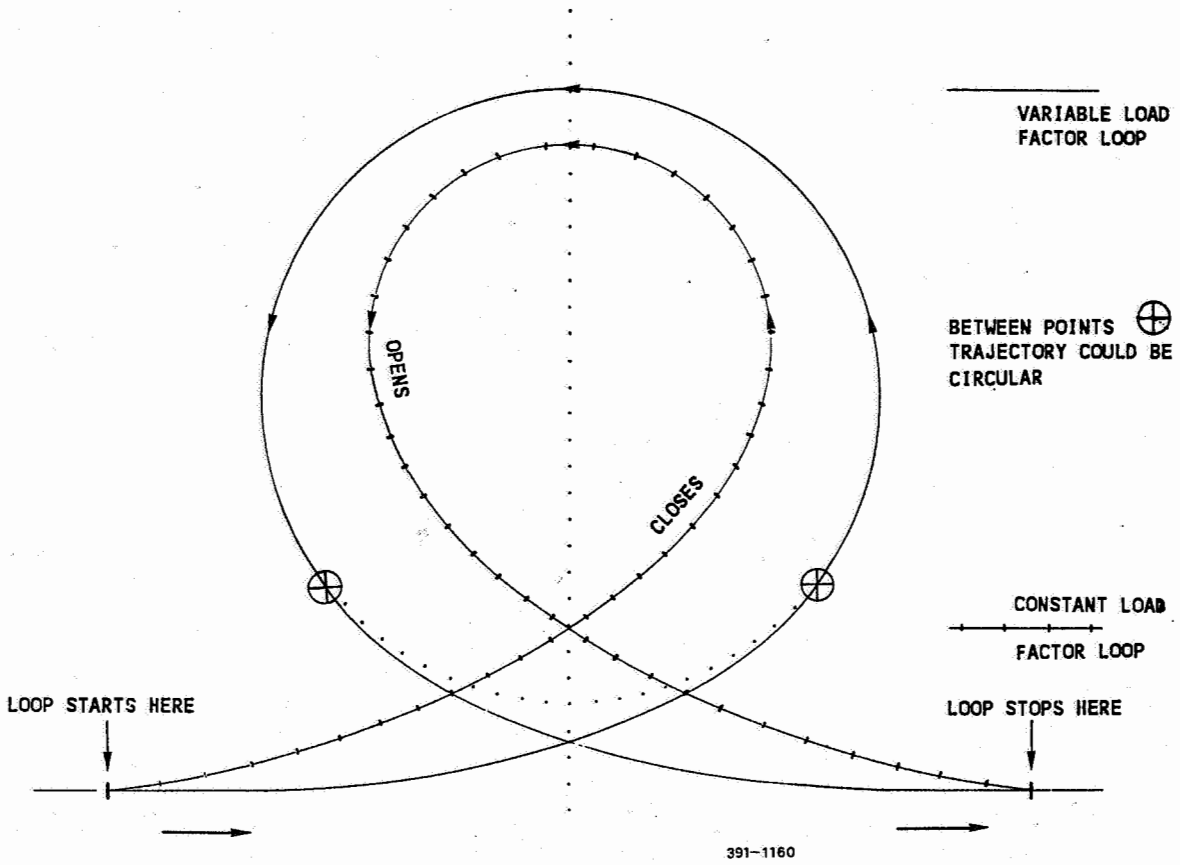
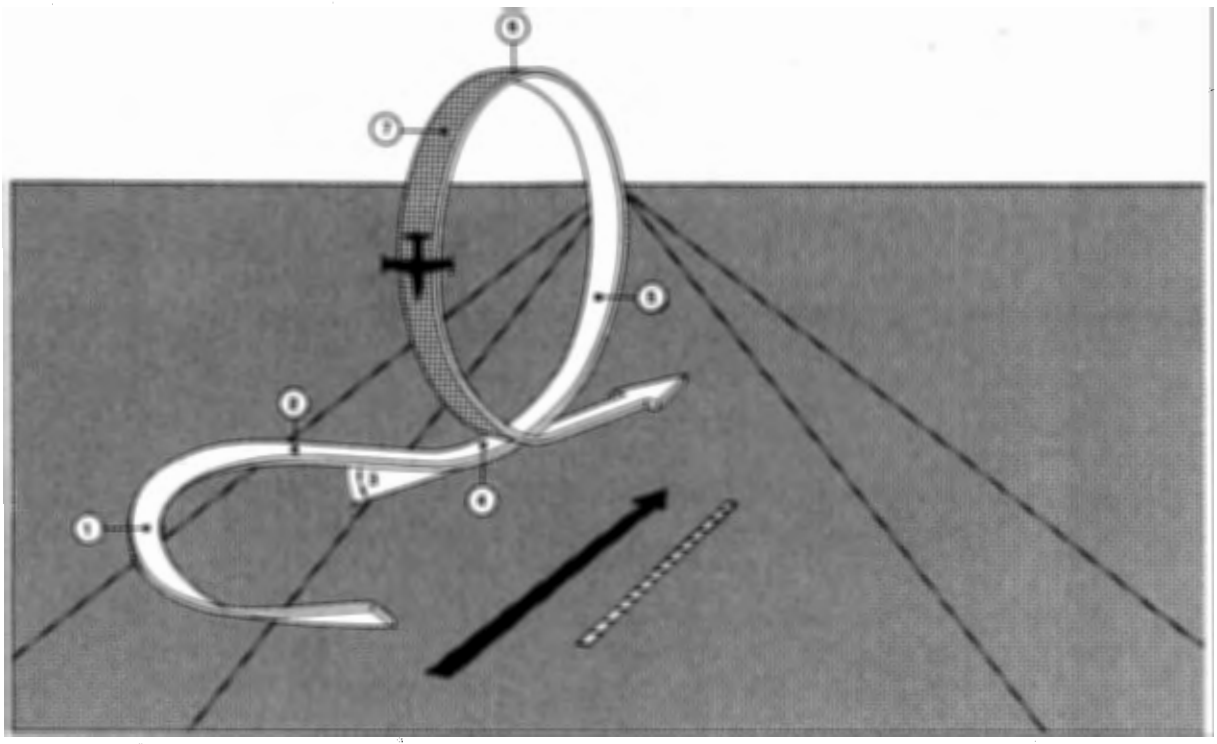


Figure 8-8. Loop (Sheet 1 of 2)



391-1161

1. PRE-ACROBATICS CHECKS, FLY PARALLEL TO REFERENCE LINE, CLEARING TURN, TRIM
2. 90% RPM
3. LOWER NOSE 20° TO 30°
4. 300 KIAS, PULL-UP
5. 3.5 G APPROX.
6. 130 KIAS AND 1 G
7. PULL AS IAS INCREASES

Figure 8-8. Loop (Sheet 2 of 2)

To make the loop rounder (though never perfectly circular), it is necessary to decrease the load factor as speed decreases (from 3,5 g to 1 g) and to increase it when speed increases again in the descending phase (from 1 g to 3,5 g).
Demonstration that the loop is not circular is given by the horizontal distance between the initial point and final point.
The speed of rotation around the pitch axis also changes considerably during the loop, from 3° per second at the beginning to approx. 15° per second in the inverted phase.

- To follow a trajectory in a vertical plane, select references allowing you to remain in this plane, such as : one reference line on the ground (a road, railway, coast line, etc.) located slightly on side of the track to be flown, for a continuous monitoring of direction, and one reference point in the sky (a series of small clouds or cirrus) allowing the direction to be maintained even when the ground below is not in sight.
After accomplishing the pre-aerobatics checks, play one clearing turn (normal turn or wing-over) to clear the adjacent space. Rollout at the selected reference, apply 90% power and enter an approx. 20° to 30° dive (as a function of the required IAS increase) to reach a speed of 300 KIAS.
With a lead of approx. 5 to 10 Kt on the specified airspeed, start to pull up so as to cross the horizon at 300 KIAS with wings perfectly level.

- In the initial phase of the maneuver, when the nose rises above the horizon to attain the first 100° of pitch, apply an increasing pressure on the stick until approx. 3,5 g are attained, while carefully checking the symmetrical position of the tip tanks with respect to the horizon; if the position is not symmetrical, the aircraft is already in a more or less tilted plane different from the maneuver vertical plane (fig. 8-9). To continue the maneuver satisfactorily, correct roll attitude and bring the aircraft in a plane parallel to the inital one checking that tip tanks are in a symmetrical position with respect to the horizon.
To maintain the envisaged load factor in the inital phase and up to a nose up attitude of 100°-110°, as the IAS progressively decreases increase the stick displacement, without changing the applied pressure.

- After completing the first phase, which is the most important one for a successfull accomplishment of the maneuver, relax back pressure on the stick to reach a load factor of nearly "1G" in the inverted phase.

WARNING

In case of abnormal decrease of the IAS due to piloting error, discontinue the maneuver and recover the aircraft in the same way as for a recovery from unusual nose high attitude.

- When approaching the inverted position, turn the head backward as much as you can to see the horizon as soon as possible (check of wings level) and the selected references (check of alignment).

- If alignment has been lost, act on the stick to close on it.

- The speed over the top must be between 110 and 130 KIAS.
Complete the over the top phase without relaxing back pressure on the stick as this would protract the inverted flight phase and lead to an exceesive deacrease in IAS. On the other hand, because of the low airspeed attained, avoid pulling too much in order not to stall.

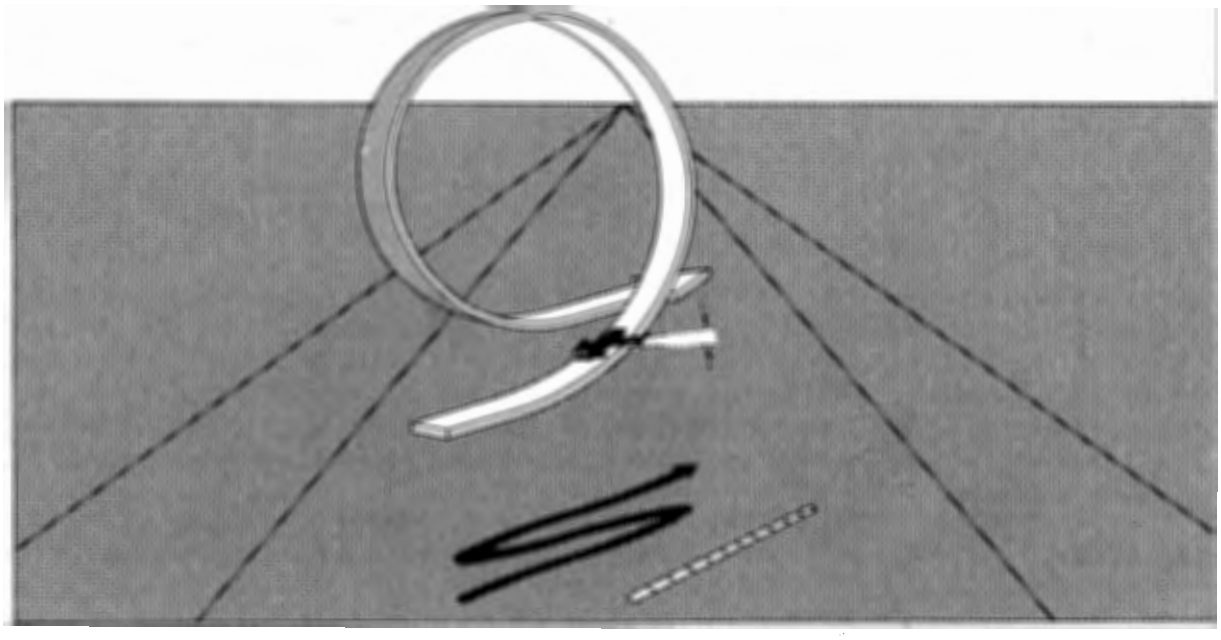


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Figure 8-9. Loop with Alignment Loss During Climb

- At the beginning of dive (after the level inverted phase with nose below the horizon), considerably and continuously increase back pressure on the stick as long as the IAS remains low. In this way, a sudden increase of airspeed resulting in the need to pull too many "G's" at the end of the maneuver will be avoided. As IAS increases, the effectiveness of the control surfaces also increases: therefore, the initial displacement aft of the stick will have to be reduced, but pressure on the stick increased.
If the aircraft should reach rapidly increasing airspeeds (due to a piloting error), proceed in the same way as for a recovery from unusual nose low attitude.

- During dive, check that the nose follows the selected reference (or is parallel to it) and proportion back pressure on the stick to regain the entry speed of 300 KIAS with a continuous and smooth maneuver.

- Do not pull more than 4g's throughout the maneuver.

- Experience will lead to perform loops at initial speeds lower than the established 300 KIAS and speeds over the "TOP" below 130 KIAS (110 KIAS approximately).

6. BARREL ROLL (fig. 8-10)

a. Description

The barrel roll is a maneuver during which the aircraft performs a 360° roll around its longitudinal axis while its nose describes a circle around one point just above the horizon. The purpose of the barrel roll is to coordinate the attitude variations when the aircraft describes a circular path around one distant point located 30° above and 30° on the side of the aircraft X axis.

b. Performance

(1) Accomplish the pre-aerobatics checks.

(2) Select a well visible reference point. Play a clearing turn and bring the aircraft to an angle of 30° with respect to the reference point (30° on the right for left barrel rolls and viceversa).

(3)Set power to 87% and head to the selected lateral reference lowering the nose as required to cross the horizon line at a speed of 270 KIAS.

(4) At this point (4) pull up and roll the aircraft to reach the maximum pitch attitude at the reference point (6) with 90° of bank. It is pointed out that in this phase the back pressure on the stick should be greater than aileron pressure to avoid an excessively flat development of the maneuver resulting in high speed in the subsequent inverted phase.

(5) Continue rolling to bring the aircraft in inverted flight (7), wings parallel to the horizon, at 30° with respect to the selected reference point, and airspeed between 130 and 160 KIAS. In this phase, relax back pressure on the stick and increase aileron pressure to keep the roll rate constant.

(6) After 270° of roll (8), the aircraft nose should be below the central reference point, with nose down to approx. 30°, and 90° of bank.

(7) From this point on, coordinate stick and rudder pressure (pro-roll pedals) to cross the horizon with wings level at a speed of 270 KIAS and the maneuver initial heading.

THE REFERENCE IS A LINE ON THE GROUND REPRESENTING THE AXIS OF THE ENVELOPE CYLINDER. ON ITS EXTENSION, VERTICALLY AND HIGH ABOVE THE HORIZON A POINT P.

1. 250 KIAS, PRE-ACROBATICS CHECKS, TRIM, FLY ABOVE REFERENCE
2. 90% RPM, SET TO AN ANGLE OF 30° WITH RESPECT TO THE REFERENCE LINE, NOSE APPROX. 30° BELOW THE HORIZON
3. AT 280 KIAS PULL UP TO 30° AND BEGIN ROLLING
4. ROLL AND PULL UP IN A COORDINATED MANEUVER
5. CROSS HORIZON WITH WINGS IN KNIFE EDGE POSITION ON THE SIDE OF THE GROUND REFERENCE, 220 KIAS
6. INVERTED FLIGHT WITH WINGS LEVEL ON THE HORIZON, OVER GROUND REFERENCE
7. WINGS IN KNIFE EDGE POSITION OVER THE OPPOSITE SIDE OF THE GROUND REFERENCE. ADJUST ROLL SPEED AS A FUNCTION OF IAS (220 KIAS)
8. OVERFLY THE GROUND REFERENCE LINE WITH WINGS LEVEL, AT AN ANGLE OF 30° AND 280 KIAS

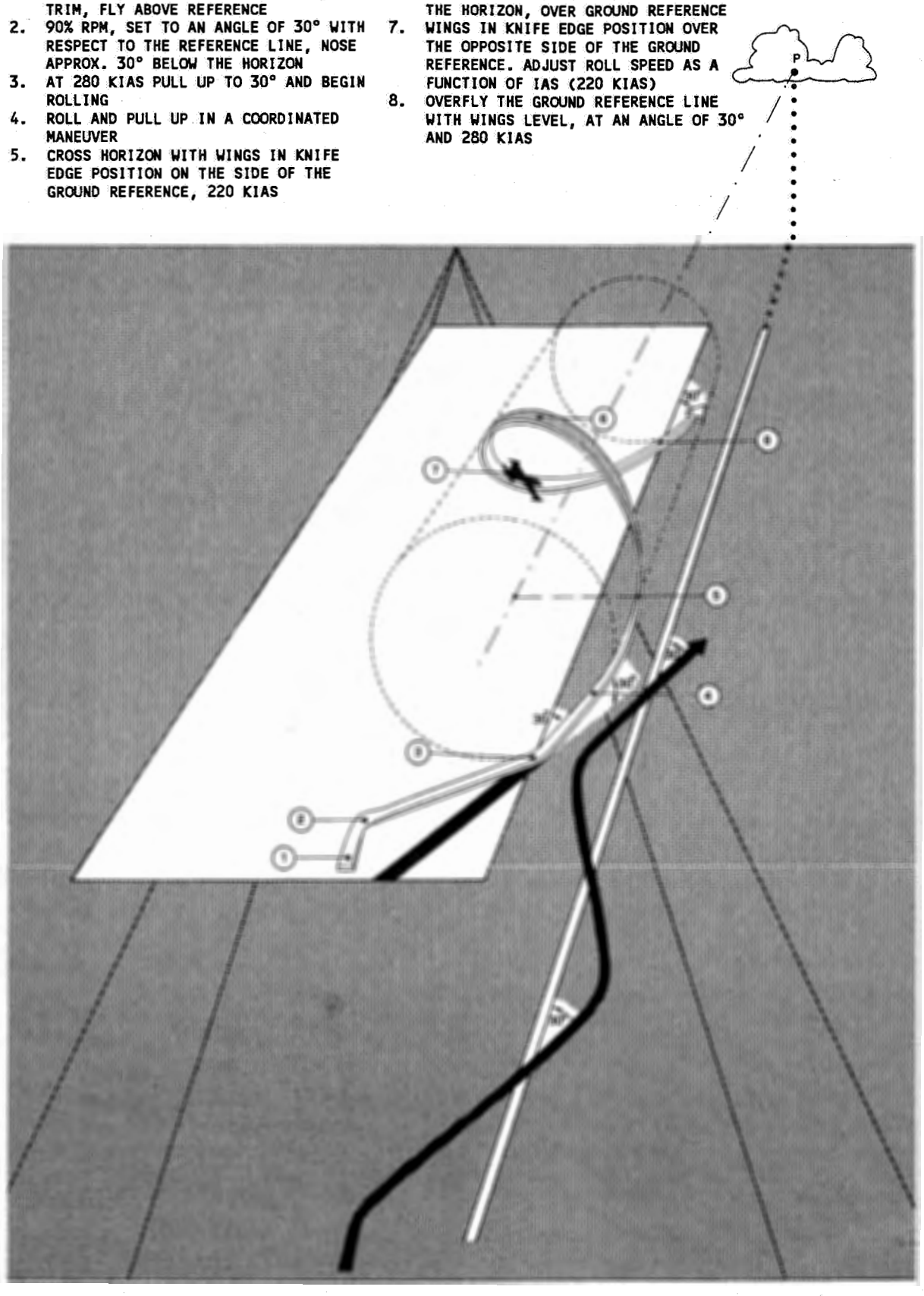


Figure 8-10. Barrel Roll

It is pointed out that in the last phase, the back pressure on the stick should be greater than aileron pressure to avoid exceeding the speed envisaged for maneuver completion.

7. SPLIT "S" (fig. 8-11)

a. Description

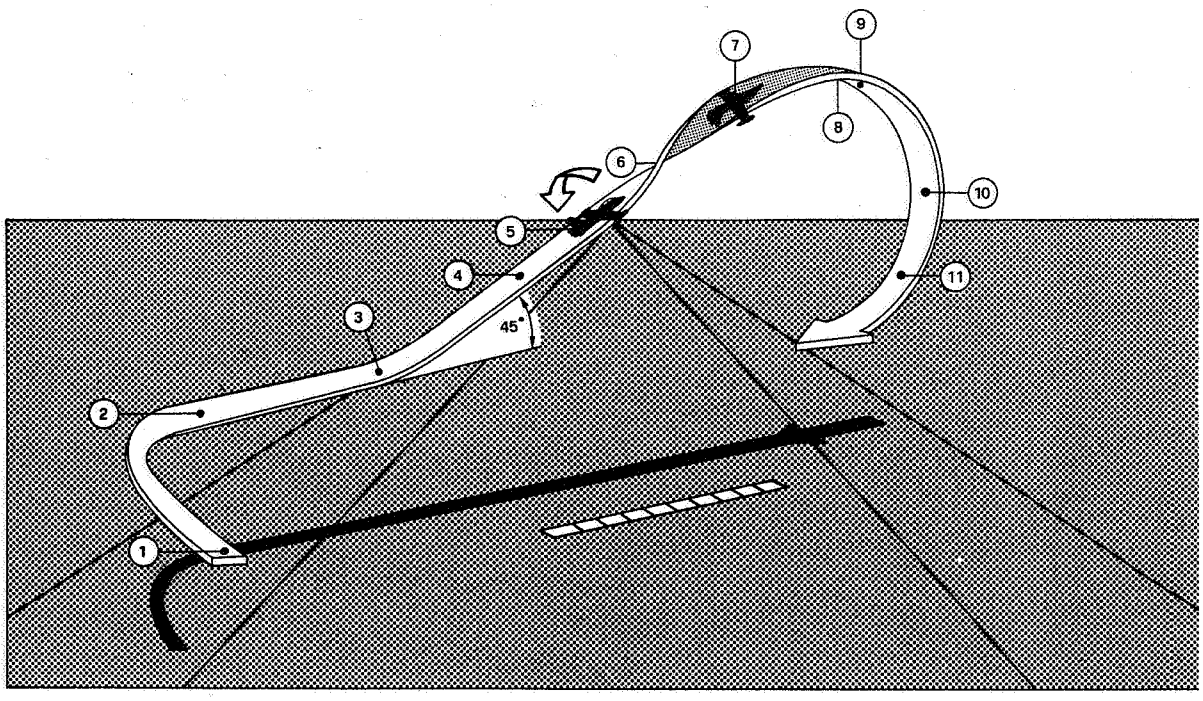
The split "S" is a vertical maneuver in which the aircraft, after an initial 45° climb, performs a 180° roll to the wings level inverted attitude followed by a 180° rotation in pitch, which is basically the same as the last half of the loop (original heading is reversed).

b. Performance

(1) Accomplish the pre-aerobatics checks and perform a clearing turn bringing the aircraft parallel or above a straight reference line with a pitch attitude of approx. 20° below the horizon, set power to 87% RPM.

(2) Raise the aircraft nose with the required lead to cross the horizon at an airspeed of 250 KIAS, and to reach a nose up attitude of approx. 45° above the horizon with wings level.

(3) Keep the attitude with controls at center: reach a speed of 170 KIAS and roll the aircraft to the wings level inverted attitude.



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1. PRE-ACROBATICS CHECKS, CLEARING TURN, FLY PARALLEL TO A REFERENCE LINE
2. 87% RPM
3. 250 KIAS
4. PULL UP 45° AND STABILIZE
5. AT 170 KIAS START ROLLING
6. CHECK PITCH DURING ROLL
7. WHEN INVERTED, CHECK WINGS LEVEL
8. 110-130 KIAS. START PULLING + 1 G
9. APPROX. + 2 G
10. + 4 G
11. 280 KIAS

Figure 8-11. Split "S"

(4)In the inverted phase, at a speed between 110 and 130 KIAS, start applying back pressure on the stick thus progressively changing the pitch attitude.

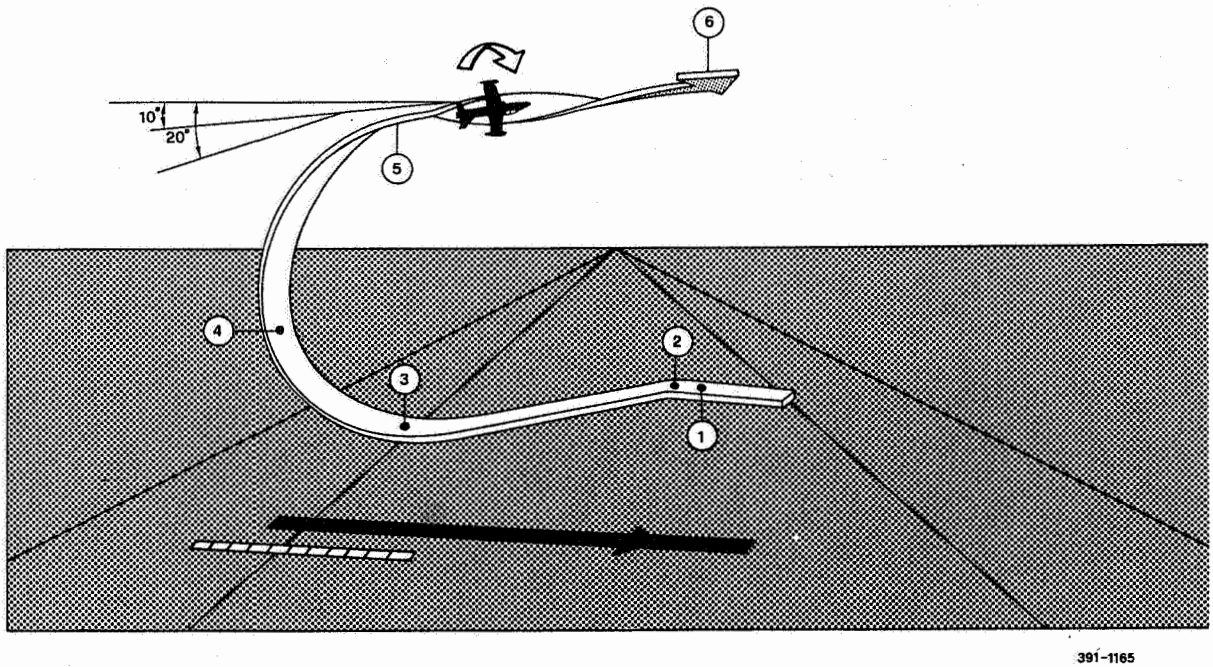
(5) As far as directional control and check of reference points are concerned, recovery is similar to recovery from the loop.
The progressive and constant variation of attitude will allow the horizon line to be crossed at a speed of 280 KIAS.

(6) It is pointed out that if the airspeed in the inverted phase is 150 KIAS or above, the maneuver must be interrupted by rolling the aircraft over 180° (half aileron roll) and applying power as required.

8. IMMELMANN (Roll off the Top) (fig. 8-12)

a. Description

The Immelmann is a maneuver during which the aircraft describes half a circle in the vertical plane and then flies a 180° roll, viz. it performs a half loop and a half roll, rolling out of the maneuver in a direction opposite to the original direction of flight.



1. PRE-ACROBATICS CHECKS, CLEARING TURN, TRIM, FLY PARALLEL TO A REFERENCE LINE
2. 90% RPM, 20° TO 30° DIVE
3. AT 320 KIAS CROSS HORIZON
4. APPROX. 4 G
5. WHEN NOSE IS 20° ABOVE HORIZON, RELAX BACK PRESSURE ON STICK, AND WHEN PITCH ATTITUDE IS -10°, START A ROLL
6. FINISH ROLL AT 130 KIAS

Figure 8-12. Immelmann

b. Performance

(1) Accomplish the pre-aerobatics checks and perform a clearing turn bringing the aircraft parallel or above a straight reference line with a pitch attitude of approx. 20°-30° above the horizon, and 90% RPM. Pull-up the aircraft with the required lead to cross the horizon at a speed of 320 KIAS.

(2) Apply back pressure on the stick to change pitch attitude in the same way as in the loop (or slightly more). In this phase, check that wings are parallel to the earth's horizon. Apply a back pressure on the stick as sufficient to avoid reaching the inverted attitude at a too low speed. If this error is made, discontinue this maneuver and fly a loop.

(3) When, in inverted flight, the aircraft nose is approx. 20° above the horizon, relax back pressure on the stick, then when roll is initiated, slightly move the stick forward: this must be done to avoid the combined effect of elevator and ailerons that would cause the aircraft to turn, thus to change direction.

(4) Check the reference on the ground and start rolling the aircraft: this second phase of the maneuver is very similar to the aileron roll but the airspeed is considerably lower. It will therefore be necessary to move controls smoothly and apply pro-roll rudder (both to maintain direction and to assist roll).

(5) When in inverted flight, airspeed should be approx. 150-160 KIAS, and approx. 130 KIAS at the end of the maneuver.
In this last phase, the stick lateral displacement must be fairly wide in view of the low speed of the aircraft and the consequent reduced effectiveness of controls.

(6) If the airspeed read in the inverted phase is lower than 130 KIAS, continue the maneuver but take care to roll the aircraft with a pitch attitude other than the optimal envisaged attitude (in extreme instances, even slightly below the horizon).

9. CUBAN EIGHT (fig. 8-13)

a. Description

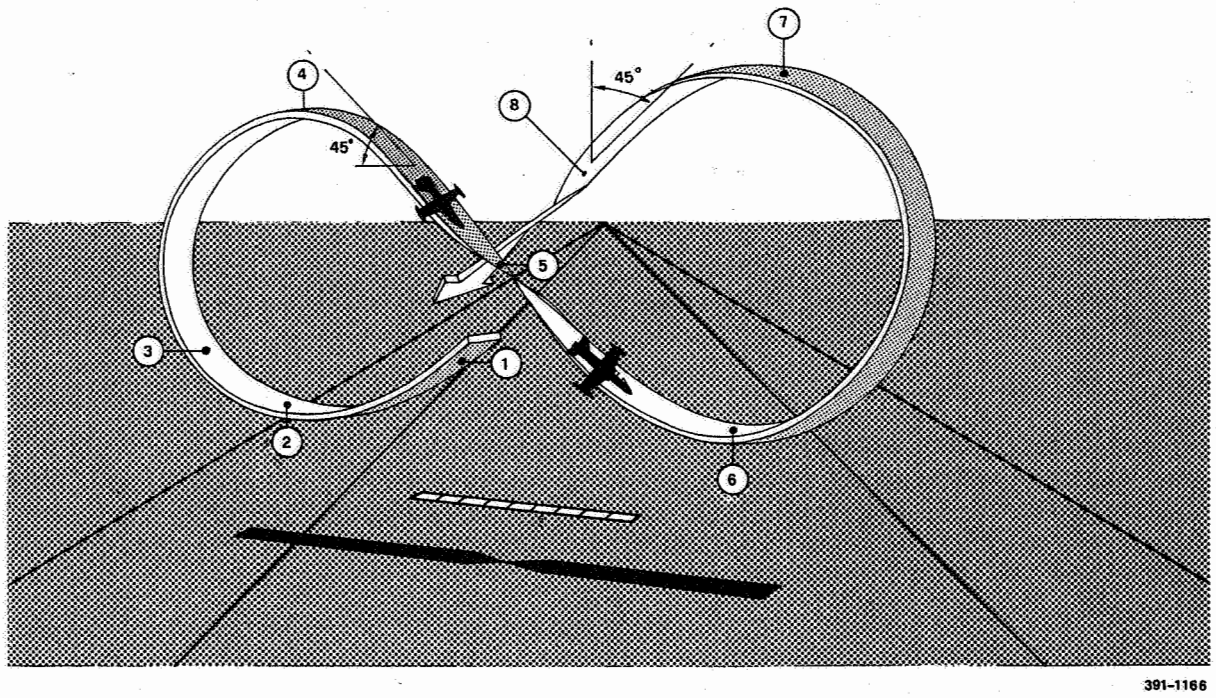
The maneuver consists of connecting two loops flown in opposite direction by means of two half rolls (in opposite directions): rolls are played in the diving half of the loop.

b. Performance

(1) After accomplishing the pre-aerobatics checks, perform a clearing turn to clear the surrounding airspace and, at the same time select a straight reference line on the ground. On rollout from the clearing turn the aircraft should be parallel to the selected reference line, and should fly with the same dive attitude and the same parameters as used to enter the loop: 90% RPM, 300 KIAS, 3,5 to 4 g.

(2) Continue the maneuver until first the inverted attitude and then 45° below the horizon are reached. To define this position, refer to a point on the ground already spotted in the inverted phase while crossing the horizon.

(3) Approaching the selected point, relax back pressure on the stick to stop rotation of the aircraft around its lateral axis at this reference.



1. PRE-ACROBATICS CHECKS, TRIM, FLY PARALLEL TO A REFERENCE LINE
2. 90% RPM, 300 KIAS
3. 3.5 G
4. 130 KIAS
5. APPLY PRO-ROLL RUDDER
6. 300 KIAS
7. 130 KIAS
8. ROLL IN OPPOSITE DIRECTION

Figure 8-13. Cuban Eight

(4) Laterally displace the stick to execute a half roll. Avoid starting the roll to right up side with nose too high or too low, or the maneuver will not be smooth enough: during pull-up, a long time would in fact be necessary to reach the proper speed, or an excessive load factor should have to be applied not to exceed the recovery IAS. Finally, roll should not be quick as pilots often tend to do: in this case it is in fact difficult to control direction and the maneuver is sharp.
Check direction with respect to the ground reference line and use rudder pressure to hold the aircraft on the desired heading.

(5) After completing rollout, neutralize the controls, then apply a back pressure on the stick to reach 300 KIAS as required to repeat the maneuver in the same way but in the opposite direction.
Upon completion of the maneuver, airspeed must always be 300 KIAS.

(6) The most common error in the Cuban Eight is the inability to hold heading during roll. This is often due to an excessive pressure on the stick: the stick must only be released not pushed or pulled.

(7) All considerations made for the loop and barrel roll are generally applicable.

10. CLOVERLEAF (fig. 8-14)

a. Description

The cloverleaf is an aerobatic maneuver consisting of 4 interconnected loops each at 90° to the previous one, in each of which is performed a quarter roll. A leaf consists of a loop and a quarter roll.

b. Performance

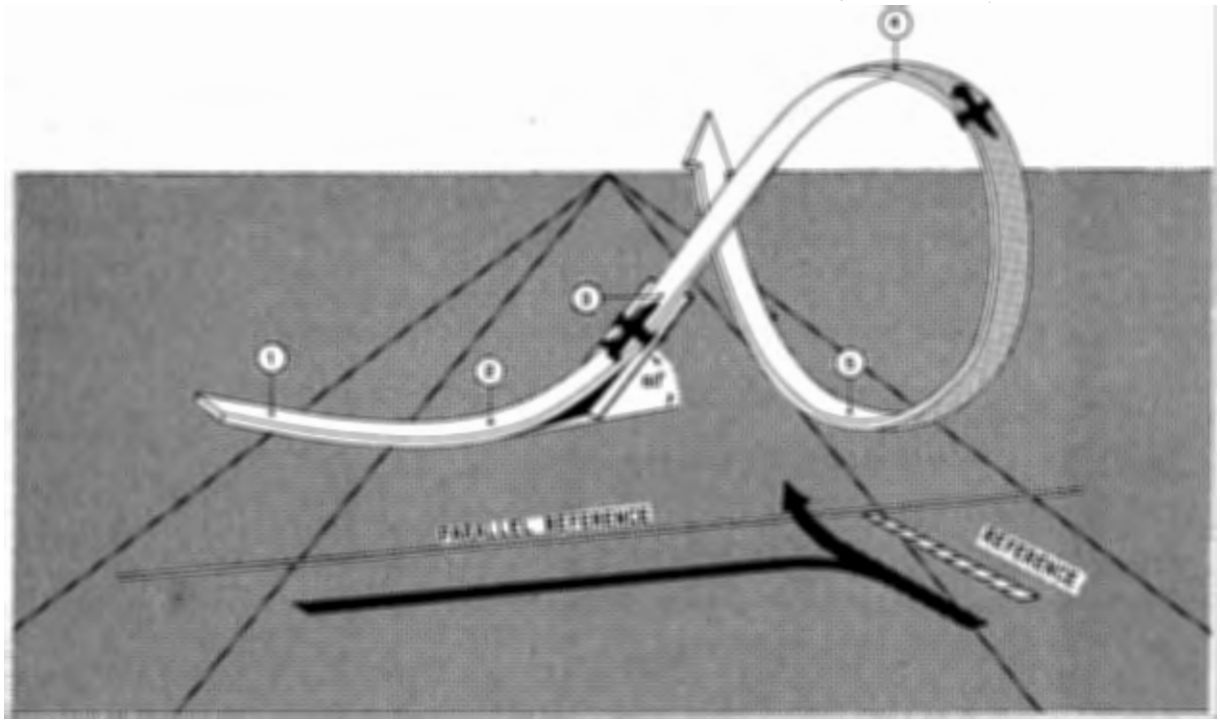
(1) After accomplishing the pre-aerobatics checks and a clearing turn, select a straight reference line on the ground (or better, two reference lines at 90°) and, at the beginning of each leaf, select a reference at 90° on the horizon (on the same side of the pullup). Bring the aircraft parallel to the straight reference line, at 90% RPM, lower the nose below the horizon to assist the speed increase and pitch up the aircraft to reach again the horizon at 280 KIAS.

(2) Continue pulling up to attain a pitch attitude of approx. 50° to 60°; do not roll the aircraft before reaching this attitude: the maneuver would be more difficult! Then, without relaxing the back pressure on the stick, roll the aircraft to the inverted attitude, which will be reached when the nose is on the horizon and the 90° turn from the original direction is complete.

During pullup, before starting to roll, carefully check the selected 90° reference point so as to have the aircraft nose pointing exactly to it when inverted. Use of the controls should be coordinated to keep the rotation speed about the longitudinal axis and roll rate constant.

(3) The airspeed over the top should be approx. 130 KIAS (with IAS> 150 KIAS interrupt the maneuver not to be subjected to a high number of "G's" or face with a considerable loss of altitude in the final phase).

(4) Continue the maneuver with wings perfectly level (as in a loop) to attain 280 KIAS when crossing the horizon in progressive pullup.



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1. PRE-ACROBATICS CHECKS, TRIM, FLY PARALLEL TO ONE REFERENCE LINE AND NORMAL TO THE OTHER (IF AVAILABLE); 87% RPM
2. AT 280 KIAS PULL NOSE UP TO 60°
3. AT 120 KIAS START ROLL
4. AT 130 KIAS, OVER THE TOP, WINGS LEVEL
5. AT 280 KIAS START MANEUVER TO ACCOMPLISH THE OTHER LEAF

Figure 8-14. Clover Leaf

(5) Continue the pullup to accomplish another "leaf" fully similar to the previous one.

(6) The aerobatic maneuver is completed after the performance of 4 "leaves"; the aircraft will have the same heading as at beginning of the maneuver.

(7) Act on controls in a coordinate way throughout all phases; bear in mind that the aircraft nose must always be moving and the maneuver must develop with a continuous and smooth variation of attitudes.

11. SPIN (fig. 8-15)

a. General

A spin is an aggravated stall during which the aircraft describes a spiral path in the downward direction.
During spin, the internal wing is subject to a more pronounced stall than the wing external to the spiral. Then, the internal wing has more drag and makes the spiral steeper, has less lift and therefore increases lateral bank.
The aircraft is forced down rolling and yawing, with nose lower and lower, until it stabilizes when the inertia forces of the masses in the fuselage and in the wings balance the aerodynamic forces.
The inertia forces tend to flatten the spin, the aerodynamic forces tend to make it steeper.
The spin of the MB-339A aircraft stabilizes after approx. three turns with approx. 50° nose low.
During spin, use of the aileron is to be avoided. In fact, the aileron that lowers instead of increasing the wing lift aggravates the stall condition and "brakes": thence, moving the stick opposite to spin, causes the spin to become steeper.
The opposite is obtained with pro-spin aileron.
The MB-339A aircraft enters spin only intentionally and has optimum recovery characteristics: it is quite possible to say that it shows a marked tendency to recover from a spin by itself if controls are left free.
The spin is taught mainly as an experience for the future, to train the pilot to promptly recognize it and to automatically proceed to recovery.
Being able to easily fly the recovery from the spin will increase confidence in the aircraft and improve the ability to orient in unusual attitudes.
The spin results from the composition of the motions of:

- translation forward and downward (gravity)
- rotation around the axis of fall
- pitch: oscillations around the lateral axis
- roll: oscillation around the longitudinal axis
- yaw: oscillation around the Z axis

Therefore, during the spin the aircraft falls, moves forward, turns, dives, rolls, and yaws simultaneously.
Aircraft control can be regained by use of the rudder and elevator.

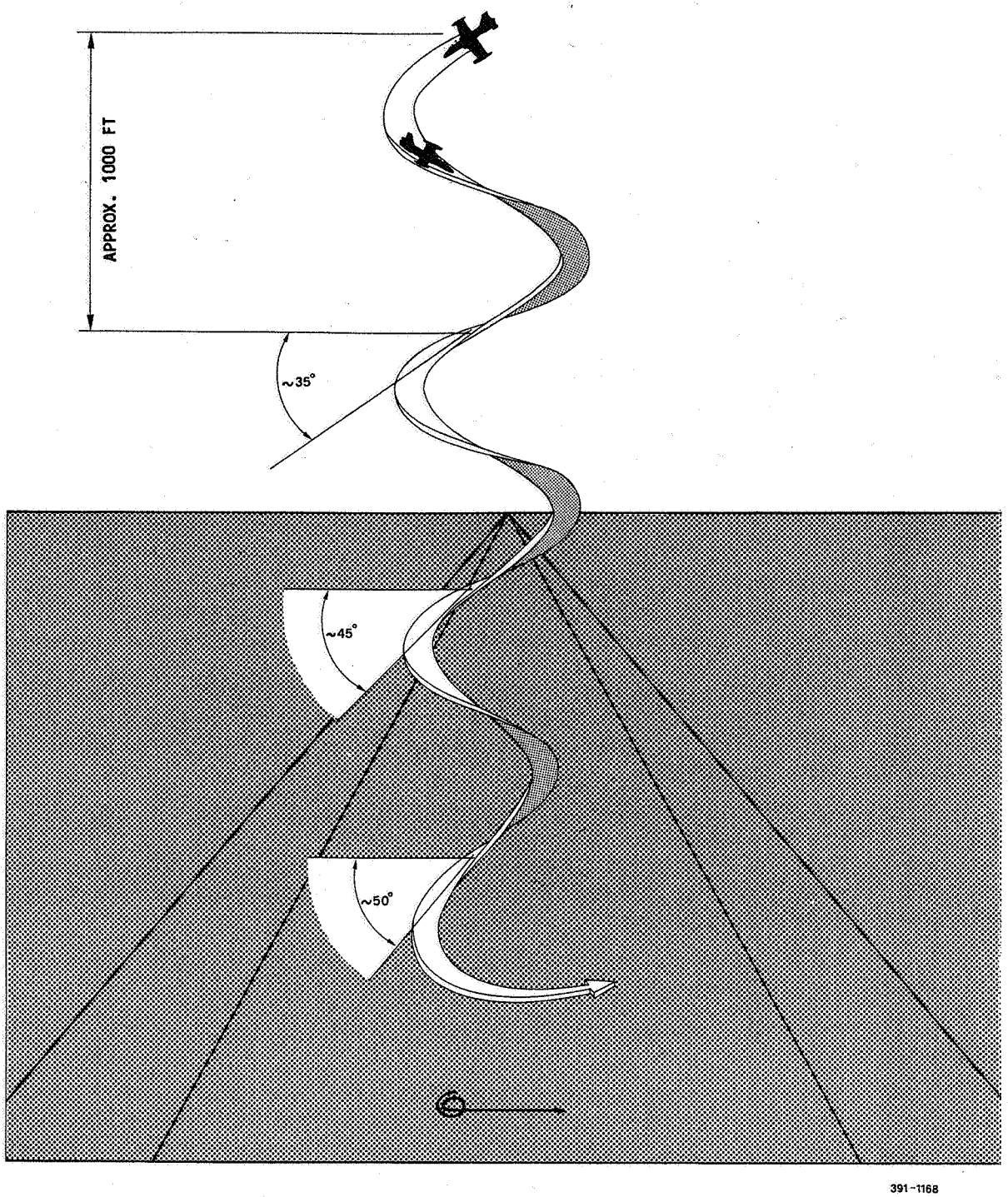


Figure 8-15. Spin

b. Performance (fig. 8-16)

WARNING

Student pilots are not allowed to perform the intentional spin with fuel in the tip tanks.

As the spin can be considered stabilized only after the third turn, training recovery will be accomplished upon completion of the third turn.

A recovery before the third turn is safe but the aircraft behaviour will change from time to time. If recovery is executed after the third turn, the aircraft behaviour will always be the same.

(1) Before performing the intentional spin, it is suggested that a clean stall be made to exactly evaluate the stall IAS.

(2) Accomplish the pre-aerobatics checks, check that tip tanks are empty and, at the same time, trim the aircraft as required for the line of flight.

(3) Retard the throttle to IDLE, but do not bring power below 60%, extend the speedbrake and perform a 180° ± 45° clearing turn with 45° of bank in the direction of the spin.
After the first 90° of turn, select a low and well defined reference point on the ground toward which the aircraft will point. Retract the speedbrake at 120 KIAS.
Throughout the turn, do not loose altitude as in this case, in presence of a slower deceleration, the aircraft may leave the cleared area or enter the spin below the minimum safety altitude. Also, do not climb, to prevent the aircraft from entering the spin with an excessive nose up attitude.

(4) Spin entry will be effected at 110 KIAS (or at a speed 10 kt above the stall speed if a stall has been executed) by applying full rudder in the desired direction of spin and, almost simultaneously, moving the stick fully back.
It is necessary to simultaneously reach full rudder and full back stick: thus, as the rudder pedals have a longer travel than the stick, they must be applied with a lead on stick application. This will help the aircraft to enter the spin correctly.

(5) During the maneuver, keep controls in the position of spin entry, viz. full back stick and full rudder, taking care to have ailerons at neutral. Bear in mind that the aircraft oscillations during autorotation tend to displace the controls, then apply an adequate pressure to avoid undesired displacements.

(6) Pay attention not to inadvertently operate the trims during the maneuver as a trim change may lead to a difficult recovery.

(7) During spin, check and count turns by referring to the known reference point.

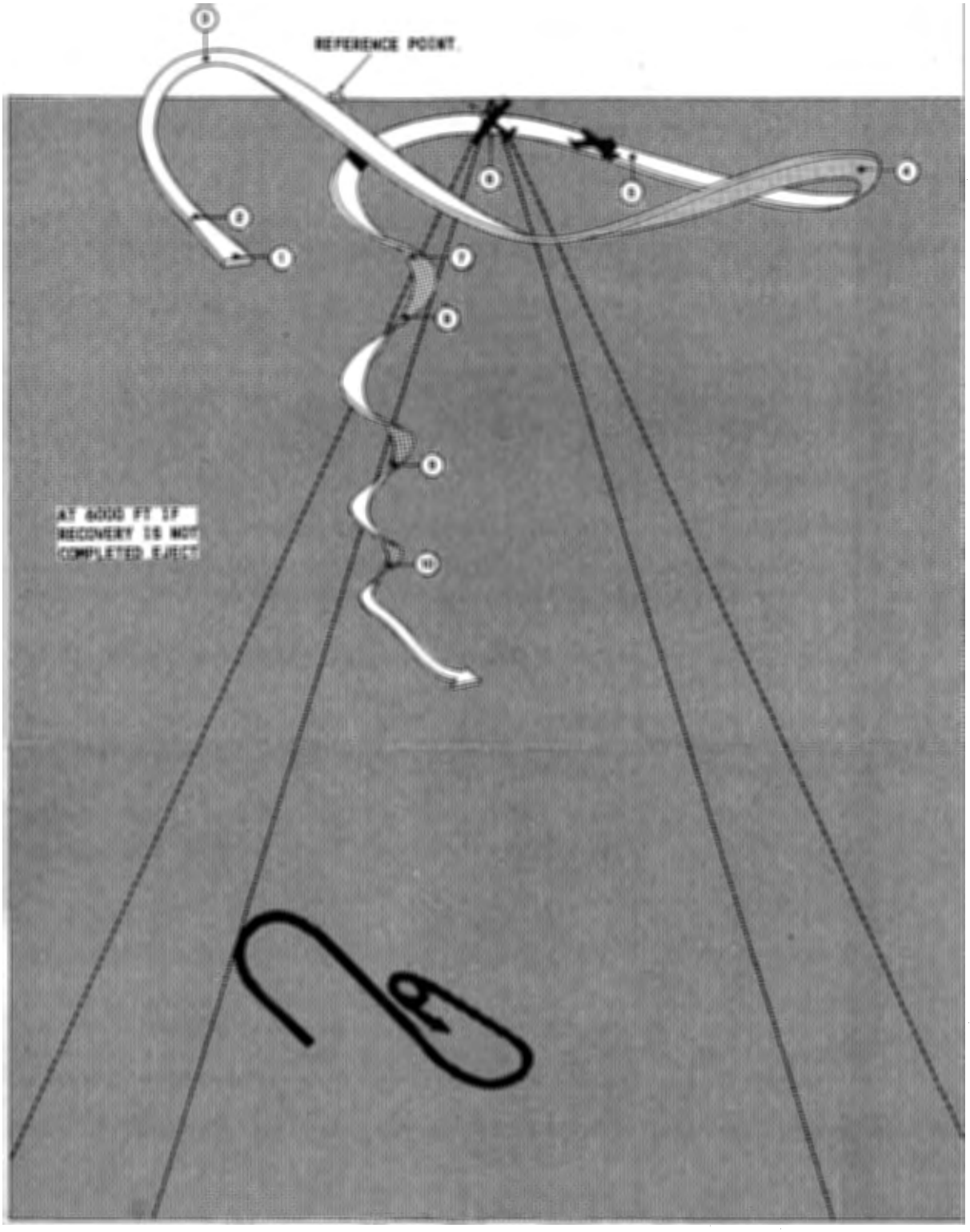
(8) Recovery will start upon completion of the third turn. Apply full rudder opposite to the direction of rotation and at the same time neutralize the stick. The rudder will stop autorotation while the elevator will reduce the excessive angle-of-attack.

As soon as autorotation stops, neutralize the rudder and start a smooth pull up to bring the aircraft back to the line of flight.
When the nose approaches the horizon, timely apply power to restore the level flight parameters.

(9) During recovery, displacement of the stick forward must be such as to avoid submitting the aircraft to negative "G's".

(10)Promptly and carefully neutralize controls as soon as rotation stops to avoid entering a spin on the opposite side during the subsequent pull up.

(11) During pull up, smoothly act on the stick to avoid a possible "G" stall. If this takes place, it will be sufficient to relax the pressure applied on the stick and proceed to a new, smoother pull up.
Airspeed at the end of a correct recovery should not exceed 240 KIAS.



1. AFTER FLYING A CLEAN STALL TO EVALUATE STALL IAS; 250 KIAS, 15000 FT, PRE-ACROBATICS CHECKS. TRIM, SELECT A FAR REFERENCE
2. SELECT POWER AT 60%
3. FLY FIRST CLEARING TURN IN THE DIRECTION OPPOSITE TO SPIN
4. FLY A SECOND TURN IN THE DIRECTION OF SPIN; SPEEDBRAKE OUT
5. STRAIGHT AND LEVEL FLIGHT, POINT TO REFERENCE. AT 120 KIAS, SPEEDBRAKE IN, HOLD ALTITUDE
6. 10 KT BEFORE STALL SPEED: STICK FULL AFT AND FULL SUDDER. DO NOT USE THE TRIM
7. FIRST TURN, COUNT TURNS
8. CHECK IAS, VERTICAL VELOCITY INDICATOR, TURN NEEDLE ON TURN AND BANK INDICATOR
9. SECOND TURN
10. THIRD TURN AND RECOVERY: STICK NEUTRAL AND OPPOSITE SUDDER, 60% RPM. AS ROTATION STOPS, RUDDER AT NEUTRAL AND PULL UP GENTLY

Figure 8-16. Spin (Procedure)

(12) In case of inadvertent spin entry, the recovery must be accomplished as soon as the nose is below the horizon, without waiting to complete the three turns: besides, the throttle must be moved to IDLE as soon as possible.

(13) In case of disorientation, it is suggested that all controls be neutralized (free). With this simple action the aircraft should recover from the spin within two turns.

(14) Any spin accomplished for training purpose must be started at an altitude above 15 000 ft. If 6000 ft are reached and the aircraft is still in uncontrolled flight: eject.

NOTE

Recovery from the spin with empty tip tanks normally takes place within half spin turn, viz. at approx 180° with respect to the recovery initial point.

c. Spin in Nose High Attitude

(1) Accomplish the pre-aerobatics checks and perform a clearing turn.

(2) Retard the throttle to IDLE and pullup to approx 50° above the horizon, point the aircraft toward a far and well visible reference point.

(3) At 125 KIAS, enter the spin by acting on controls just a little more rapidly than in standard spin.

(4) The aircraft will accomplish a first turn similar to a steep climbing aileron roll: the second turn will be almost on the horizon line, the third one with nose down.

(5) During spin, positively keep the controls against their stops.

(6) After 3 turns, recover by following the standard procedure.

d. Inverted Spin

The intentional inverted spin is an advanced aerobatics which is strictly prohibited to student pilots.
The probabilities that the aircraft may accidentally enter an inverted spin due to incorrect piloting at very low speed are negligible and the simple release of the controls, even if not at neutral, causes the aircraft to enter an erect spin, from which it can recover spontaneously too.
Performance of and recovery from the inverted spin are described in FM, Section VI.

12. COMPOSITE AEROBATICS (fig. 8-17)

Composite aerobatics consists of at least 4 aerobatic maneuvers connected to each other, viz. performed with continuity.

(1) Accomplish the pre-aerobatics checks, select the reference points and stabilize power at 90% upon completion of a clearing turn.

(2) Fly the recovery from each maneuver so as to reach the attitude and airspeed envisaged for the following one.

(3) It is very important to select the right sequence of maneuvers. It is necessary to choose maneuvers requiring increasing entry speeds and developing such as not to interrupt the gradual and continuous variation of attitudes.

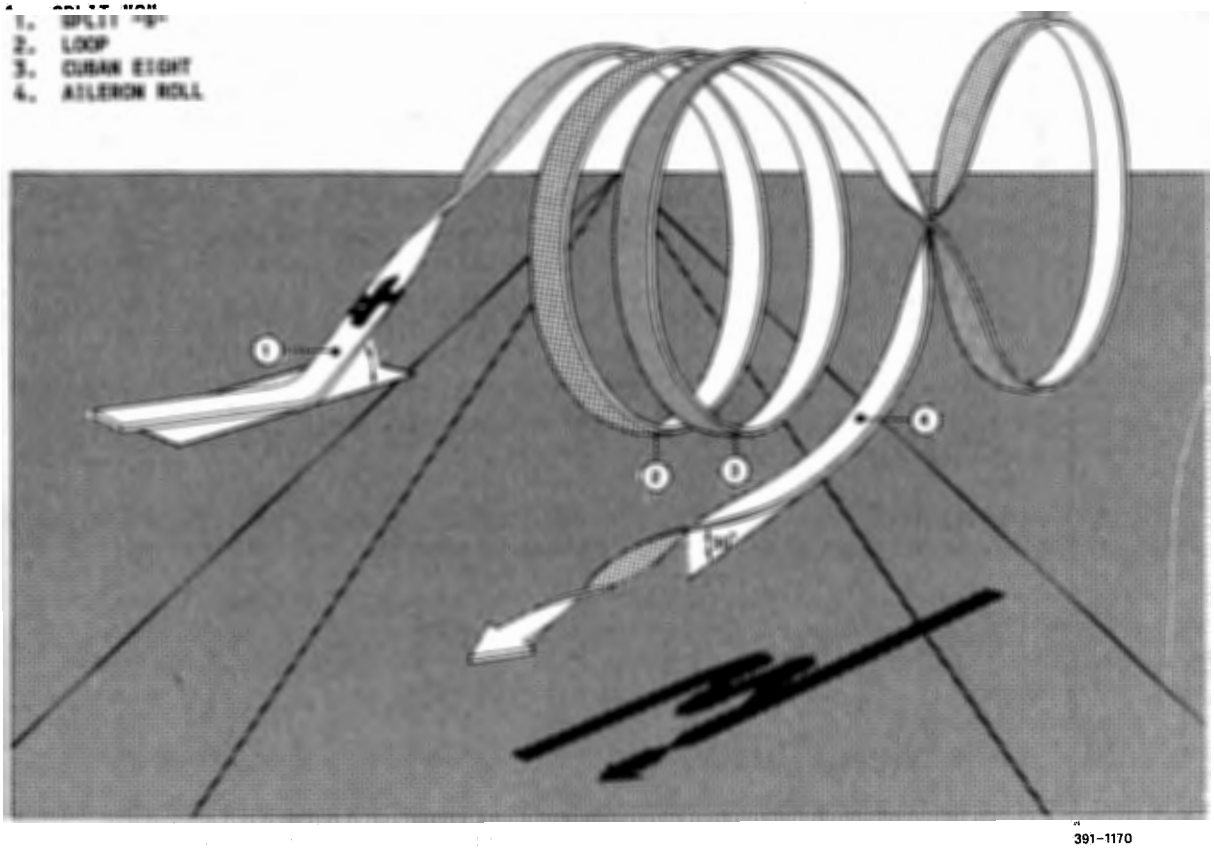


Figure 8-17. Example of Composite Aerobatics

(4) Bear in mind that the subject maneuvers must appear to be sequential: if, at the end of one maneuver, the parameters required for the subsequent one are not reached, do not interrupt the sequence but conveniently act on controls to reduce or cancel the error.

Composite aerobatics is the final aim of basic aerobatics: the mechanical performance of piloting actions must be replaced by a skillful and confident piloting technique: gradualness and smoothness of coordination therefore become much more important than strict adherence to the parameters.

13. MANEUVRABILITY AND AEROBATICS AT HIGH ALTITUDE

a. Maneuvrability at High Altitude

(1) The most considerable effect of altitude increase is the reduction of the engine thrust. Besides, the range of usable indicated speeds is smaller because the limit Mach number is attained at a much slower IAS than at low altitude, while the indicated stall airspeed remains the same.

(2) Though the maximum allowable IAS decreases, the TAS increases.

(3) It is important to refer to the Machmeter as the Mach number is in a direct relationship to the TAS.

(4) Maneuvrability at high altitude is reduced because of the:

- IAS/TAS relationship,
- reduction of the lift coefficient at high Mach numbers
- reduction of thrust

(5) The reduced lift at the lowest IAS's and the concurrent high TAS, limit the load factor that can be applied before the aircraft stalls. In view of the fact that every variation of flight direction is obtained by applying a load factor, every limit set on the "G's" results in less maneuvrability.

(6) The acceleration from wings level to maximum roll rate is lower at high altitude because controls are less responsive at the IAS normally flown at the high flight levels. The deceleration from the maximum roll rate to the wings level condition is also slower.

NOTE

Use of full aileron pressure to control roll rate may lead to a wing stall.

(7) For every IAS and angle of bank, as altitude increases the turn radius increases and the turn rate (°/min) decreases (fig. 8-18).

(8) The reduction of the available power further reduces the aircraft capability of flying steep turns. This capability, is already limited by the fact that the bank angle, thence the load factor, is a function of the TAS, which is high, whilst the low IAS requires low load factors, thus shallow turns.
The shallow turns at high TAS have large radius and small rate of turn.

(9) The visibility at high altitude is deceptive (unless in visual contact with condensation trails). Although it is possible to see and recognize points on the ground at a distance of 100 NM, it is difficult to see another aircraft: this is due to the fact that the human eye sighting in the space tends to focus to distances slightly over one meter (empty space myopia). The phenomenon ceases if in the space being observed there is a cloud, a trail, another aircraft, etc. It is however well known that it is positively difficult, even for an observer on the ground, to locate an aircraft in the sky.
This brings about the need to carefully and frequently look out.

WARNING

The oxygen at high altitude is life. Above 10 000 ft of cabin altitude (FL 220), the lack of oxygen begins to bear negative effects on the pilot's attention, readiness, etc. When flying at FL 360 with cabin altitude of 20 000 ft, total lack of oxygen is an extremely serious emergency and can be fatal (the pilot loses consciousness without realizing it and is incapable of any reaction). Refer to FM, Section III.

b. Aerobatics at High Altitude

(1) Aerobatics at high altitude (above 30 000 ft) are to be performed dual.

(2) As to climb, remember that to exceed the vertical limits of the airwork area it is necessary to obtain a clearance from the "Approach".

(3) The MB-339A aircraft shows a good maneuvrability also at very high altitudes: however, control of attitudes, especially roll, is more difficult.

(4) Vertically developed aerobatics above 30 000 ft give rise to compressibility problems that are not apparent at lower altitudes. The higher the altitude is, the higher is the TAS for a given IAS, and therefore turn radii are greater.

Moreover, the difference between IAS and TAS increases in vertical maneuvers (such as loops), in which case it is maximum over the top (the altitude gains generates TAS increases).

(5) The typical maneuver to check maneuvrability at high altitude is the loop, which is to be entered above 30 000 ft. Perform the checks, lower the nose to obtain a slight dive and attain Mach 0.76. Apply a light back pressure on the stick to raise the nose as pulling too many "G's" would cause a compressibility stall. Initially, the vertical velocity (rate of climb) is modest: as the Mach number decreases, it is possible to increase back pressure on the stick until the first stall vibrations are felt.
A slight vibration of controls can be noted as speed decreases, especially during transition from the flight just below the compressibility IAS to the flight just above the stall IAS.

(6) The stick must be pulled aft fairly sharply during the first half of the maneuver.
Over the top, the IAS can be really low, even below the stall speed. If a pressure sufficient just to keep slightly positive "G" is applied, the aircraft should not stall: it will in fact fly a ballistic trajectory.

(7) At high rpm, the engine has the effect of a gyroscope with a considerable rotating mass at high rpm. As the aircraft translation speed over the top is very low and there is a dive rate increase, it will be possible to perceive the engine gyroscopic effect; this causes the nose to turn to the right. Maintain direction with the rudder and ailerons.

(8) In dive, increase back pressure on the stick to attain the "buffeting" limit in order to avoid reaching a high Mach number and, when "G's" are too high, relax pressure to prevent compressibility stall. Reduce power and, if necessary, extend the speedbrake.

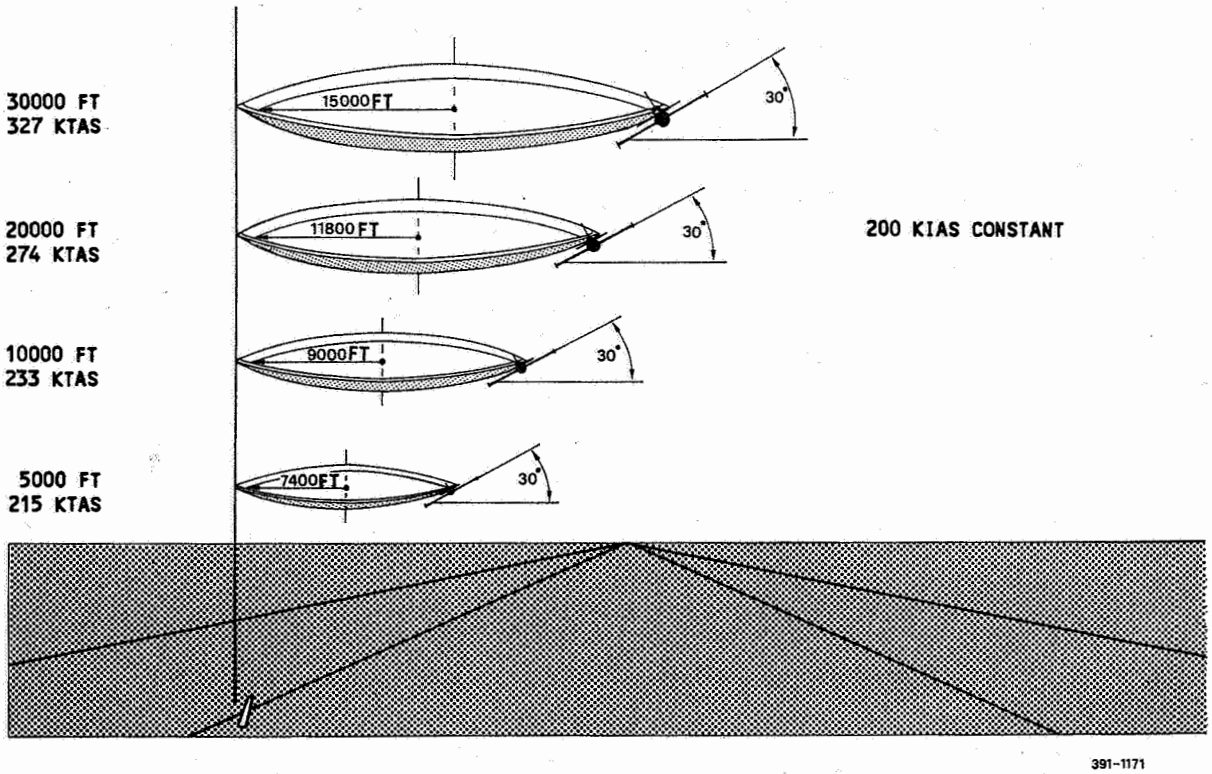


Figure 8-18. Turn Radius With Constant Bank and IAS

(9) When the nose approaches the horizon, slowly increase power to limit the altitude loss, and increase airspeed for the subsequent maneuver.

(10) If critical attitudes are attained and the danger of compressibility arises during the maneuvers, immediately apply the correct recovery procedure, using the speedbrake if necessary.
The maneuvers to be accomplished at high altitude are as follows:

- wingover: 90% RPM, entry at 270 KIAS, normal development, approx. 105 KIAS speed over the top, recovery at the entry airspeed.

- loop: 90%RPM, entry at 270 KIAS, initial load factor approx. 3 g, approx. 60 KIAS speed over the top, recovery at the entry airspeed.

- Immelmann: 100% RPM, entry at 270 KIAS, initial load factor approx. 3 g, roll the wings with the aircraft nose slightly below the horizon line at a speed not lower than 90 KIAS.

WARNING

During the maneuvers at high altitude, frequently check the blinker, the connections and oxygen supply.

14. OTHER AEROBATICS

Some aerobatics are demonstrative only and have a limited training value. Generally, these aerobatics are not taught to student pilots. Some of these maneuvers are considerably difficult and are classified as "advanced aerobatics".

a. 90° Aileron Roll

It is a wingover followed, after the aircraft has accomplished a 90° turn, by an aileron roll in the same direction of the turn. Performance:

(1) Accomplish the pre-aerobatics checks and perform a clearing turn.

(2) Select a point far abeam.

(3) 87% RPM. Slightly dive to reach 280 KIAS.

(4) Pull up smoothly up to an acceleration of 3 g.

(5) When the aircraft crosses the horizon, start banking smoothly as in the "cloverleaf".

(6) When the aircraft has reached 60° of turn, 60° of pitch and 60° of bank, apply full stick on the same direction of the turn until the aircraft reaches the inverted attitude after 90° of turn; keep the nose up by slightly moving the stick forward.

(7) Coordinate stick and rudder inputs and continue the second half of the roll slowly, on the line of flight.

b. Fiesler (from the German Pilot Fiesler) or Vertical Reverse (fig. 8-19)

It is a very low speed turn played in the vertical plane after a zoom. Performance:

(1) Accomplish the pre-aerobatics checks and perform a clearing turn.

(2) Select a reference line and bring the aircraft parallel to it.

(3) 90% RPM. Take a dive attitude (20°).

(4) Start the pullup at 290 KIAS to cross the horizon at 300 KIAS, 3,5 g.

(5) Perform the first part of the maneuver in the same way as for the loop.

(6) With 80° to 85° nose high, move the stick forward as sufficient to hold the nose up attitude very close to 90°, but not beyond.

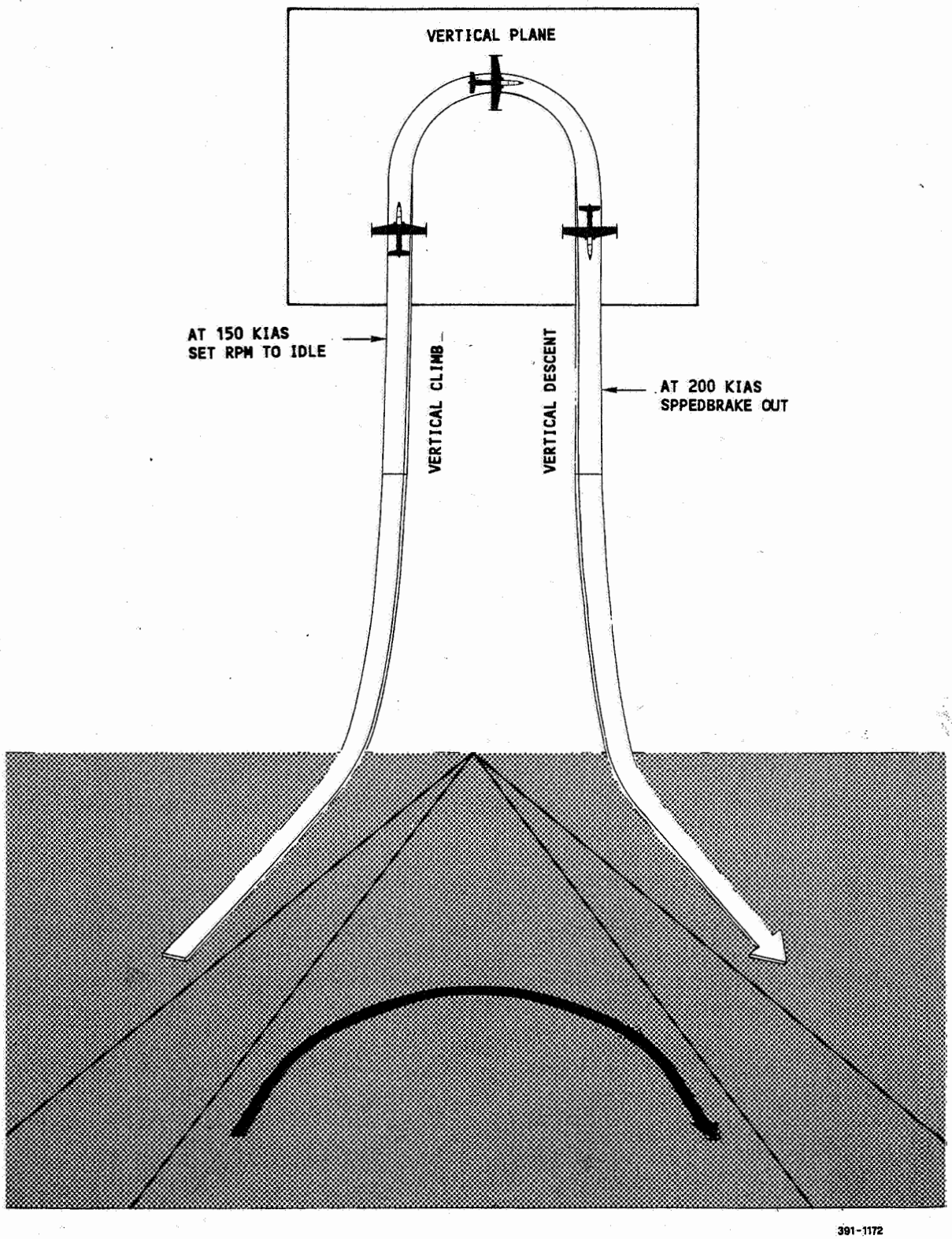


Figure 8-19. Vertical Reverse

(7) The speed will decrease rapidly. At 150 KIAS, reduce power to IDLE quickly but not sharply. At 115 KIAS, apply full rudder in the direction of the turn.
The aircraft will rotate in the vertical plane by 180°.

NOTE

To keep the aircraft in the vertical plane, it can be necessary to apply lateral pressure on the stick in the direction opposite to the turn.

(8) Return the rudder to the center just before the aircraft reaches the vertical position. Start pulling first smoothly, then resolutely, starting from 150 KIAS with an attitude of approx. 85° nose low.
If necessary, extend the speedbrake above 200 KIAS.

(9) Apply power and retract the speedbrake when the aircraft is almost in level flight, and stabilize at 250 KIAS.

c. Whipstall

It is a vertical climb of the aircraft followed by a pause, an abrupt uncontrolled rotation around the pitch axis and by a controlled vertical dive.
The first part of the maneuver is identical to the Fiesler.
Performance:

(1) Accomplish the pre-aerobatics checks and perform a clearing turn selecting a straight reference line. Align the aircraft on the reference.

(2) 90% RPM. Starting from 250 KIAS, pullup up to 70°-80° above the horizon.

(3) At this attitude, neutralize the controls and retard the throttle to IDLE.

(4) Allow the aircraft to climb vertically until it stalls. Below 90 knots it will be practically useless to act on the controls (except for the rudder pedals), the nose up attitude must therefore be controlled before the loss of control.

(5) When the nose drops, smoothly release the stick forward and control direction with the rudder.
If the maneuver is accomplished perfectly, the aircraft will slip back a few meters, and suddenly drop nose downward.
The stick must be at neutral in order to stop whipstall at approx. 80° of dive. (The aircraft will show a tendency to oscillate around the vertical: it will have to be controlled very smoothly).
At 115 KIAS, the aircraft will return to be controllable. At 150 knots it is possible to start recovery in the same way as for the vertical reverse.

d. Schneider Turn

Refer also to Chapter VI, para 3.d.
It is an extremely steep turn with a load factor of "5g" or more, start the maneuver at 100% RPM and at least 360 KIAS, lateral bank is approx. 78°.
Airspeed will decrease during the turn.
Altitude will be maintained by slightly increasing or decreasing bank while applying back pressure on the stick to maintain a load factor of 5 to 5,5 g.

The turn will be accomplished at 12° to 15° per second, with a radius of approx. 800 meters. The maneuver is completed after 360° of turn without loss or gain of altitude.

e. Half Roll and Back

Start a standard roll maneuver. When the aircraft attains the inverted attitude, quickly neutralize the stick and continue flying inverted with wings level and nose above the horizon for approx. one second.
Then move the stick to the side opposite to the first half roll and return the aircraft to the line of flight by controlling the direction with the rudder (apply rudder pedals just as sufficient, in the direction opposite to the stick displacement).

15. LOOP WITH NON-STANDARD PARAMETERS

a. With Throttle at IDLE

(1) Accomplish the pre-aerobatics checks and perform a clearing turn.

(2) Attain a speed of 270 KIAS and retard the throttle to IDLE when crossing the horizon.

(3) Accomplish a straight pull up with load factor of approx. 4 g.

(4) The airspeed over the top is very low and to avoid stalling it is necessary to move the stick a little forward of neutral.
In this phase, check the AOA indicator which will provide useful indications to avoid exceeding the critical angle-of-attack.

(5) When starting to descend, plan a straight track on the ground, observe the points that will be reached and overfly them with the aircraft nose.

(6) Change the attitude constantly (however more slowly than in the standard loop) to regain 270 KIAS.

b. With 100% Throttle

(1) Accomplish the pre-aerobatics checks, perform a wingover and, upon completion of wingover, set power to 100% RPM.

(2) Coordinate the pullup to cross the horizon at 220 KIAS, then accomplish a zoom with a load factor of approx. 4 "G".

(3) The airspeed over the top will be rather low. Check the AOA and change the pitch attitude at the limit of buffeting.

(4) Plan and follow the descending track.

(5) Change the pitch attitude constantly to regain 220 KIAS.

PART TWO - CHAPTER IX

EMERGENCIES AND SIMULATED EMERGENCIES

TABLE OF CONTENTS

Title	Page
Introduction	9-1
Actual Emergencies	9-1
Simulated Emergencies	9-13
Concurrent Emergencies	9-14
Command to Abandon the Aircraft	9-15
Complete Electrical Failure	9-15
Interphone System Failure	9-15
Airspeed Indicator and/or Altimeter Failure	9-16
Post-Landing Assistance for Emergencies	9-16
Loss of Orientation	9-16

1. INTRODUCTION

The procedures to be followed in case of in-flight and ground emergencies are described in the FM, Section III and are divided as follows:

- General procedures
- Ground emergencies
- Takeoff emergencies
- In-flight emergencies
- Landing emergencies
- Miscellaneous emergencies

The FM does not cover the operational emergencies such as fuel level low, impossibility of establishing the geographical position ("lost pilot"), etc. which will therefore be considered in this manual.
The student pilots are obliged to commit to memory Section III of the FM. Many of the emergency conditions contained in Section III can be simulated for training purposes.
Chapter IX has the purpose of describing the simulated emergencies in detail, of providing the supplementary information necessary to accomplish the emergency procedures that cannot be simulated (ejection), and of prescribing the procedures to be followed for "operational" emergencies.

2. ACTUAL EMERGENCIES

a. General

The procedures outlined in this chapter are only intended to supplement those contained in the FM, Section III. These additional procedures could be useful while performing any flight activity in the MB-339A, and in particular the training activity at the Flying Schools.

(1) In general, it can be said that no emergency should upset the

coolness and self-confidence of the pilot who thoroughly knows the systems, the limitations of the aircraft and his own.

(2) When the emergency occurs, if time permits, advise the runway mobile control, the TWR or the OPS room of the nature of the emergency, and provide all the necessary information to enable the groundcrew, who are in charge of this task, to take measures to safeguard the pilot, the aircraft and themselves.

b. Complete Radio Failure

If a failure of all radio sets is suspected, accomplish all required blind radio calls. If only the receiver operates correctly, follow the received instructions, if any. When the aircraft with failed radio equipment is outside the traffic pattern, the pilot must behave as follows:

(1) If he does not exactly know the QFU at the destination airport, he should overfly the airport without interfering with traffic (min altitude 3000 ft) to observe the signal area and the wind sock. The heading of the runway in use is the one indicated by the landing "Tee".

(2) Enter the pattern by following the local regulations. Reach initial at 1500 ft AGL; rock the wings alongside of the runway, watch the traffic and the light signals from the tower (or the runway mobile control).

(3) Perform break at the approach end of the runway and proceed to a normal landing checking the traffic and the light signals from the tower or the runway mobile control; plan a final for a "full stop" landing and land with all external lights on.

(4) If obliged to go around: follow the go around procedure bearing in mind that the barrier could be up.

(5) If required to fly a closed pattern, clear the area for aircraft taking off, landing or on pattern.

(6) If radio failure is ascertained prior to takeoff, reach the holding position and await for light signals from the tower or the mobile control to taxi on the runway and return to the parking area.

c. Barrier Engagement

If you feel you are loosing directional control: engage the steering.

d. Fire during Starting

EJECT from the aircraft only if the fire reaches the cockpit and the following conditions exist:

- the pilot is securely fastened to the seat with the harness straps and the leg restraint lines;
- the canopy is closed and locked.

In all other cases, carry out the procedure described in the FM, Section III.

e. Blown Tire during Takeoff

If you feel you are loosing directional control: engage the steering and hold rudder at neutral.

f. Ejection after Accident on the Ground

With aircraft stopped or almost stopped and damaged on the ground, it is possible to eject also under the following extreme conditions:

- aircraft banked up to 70°.
- aircraft nose down up to 45°.

g. Oxygen System Failure

Pay attention not to mistake the symptoms of hyperventilation, which is an excessive rate and depth of respiration (the oxygen system is in operation), and is mainly due to fatigue and stress, for the symptoms of anoxia (failed oxygen system).
Hyperventilation may result in pilot's fainting and is as dangerous as anoxia.
As hyperventilation or anoxia are first suspected, if flying dual, immediately advise the instructor, then move the oxygen diluter lever to 100%; in serious cases, also move the "EMG" lever (emergency oxygen) forward. Then breathe slowly until symptoms disappear.
In case of solo flight, state the emergency and request to descend to a cabin altitude below 10 000 ft (approx. 20 000 ft QNH), and land as soon as practical.

h. Landing Emergencies

Remember that, if there is any chance to accomplish a flame-out landing, the pilot should try to do so down to a very low altitude. The IT 10F ejection seat allows pilot's ejection also at a few feet above ground. It is however prescribed that the ejection be accomplished at least at 150 ft (50 meters) AGL.
Decision to eject must be taken at 800 ft AGL.

i. Forced Landing on Rough Surface

The recommendation given in the FM, i.e. to eject rather than trying to land on a rough surface is to be understood by student pilots as a command to eject, even at very low altitude.

j. Hydraulic System Failure

Indication between 70 and 150 bar on the pressure gauge of the main system.
The student pilots must move the "AIL SERVO" switch to OFF.

k. Aileron Servo-control Failure

Reduce airspeed below 350 KIAS.

l. Asymmetrical Fuel Transfer

Continue the flight until you start the descent to the airfield where you intend to land (as a function of the reduced range). Then, if the tip tanks are in an unbalance condition, dump the fuel. If the underwing tanks are in an unbalance condition, land with extreme caution (the aircraft can be trimmed in roll to a minimum speed of 95 KIAS and can be controlled at 87 KIAS, with full aileron), maintaining an approach speed and a touch-down speed 5 knots higher than usual.

m. Power-off Glide

This procedure is applicable also to glide with engine that does not provide sufficient thrust.
Maintain 150 KIAS or, better, AOA 0.42, i.e. the pointer on the lower margin of the white approach mark.

n. Basic Procedure for Forced Landing (Actual) (fig. 9-1)

The forced landing is the procedure (fig. 9-2) that permits the aircraft to be brought to landing in case engine thrust is unsufficient to continue the flight, or of engine flame-out.
The immediate action to take is to trade airspeed for altitude by a progressive and smooth pitch up action, until 150 KIAS (fig. 9-3) are attained. Check that the AOA indicator reads approx. 0.42; trim the aircraft for this attitude and, while investigating the cause of the failure (lack of fuel, mechanical failure, piloting error, accidental retarding of throttle), head to the nearest airfield.
Position the UHF or VHF radio on the guard/emergency channel. Advise failure, position, altitude and your intentions with a very short message, which should not jeopardize the subsequent attempt to relight the engine.
Example of message:
Jumbo. This is Lion eight-two. Flame-out at 250 level, overflying Silver; attempting engine relight. Over.

(1) Within 30 seconds from engine flame-out (provided there are no clear indications of engine mechanical failures), attempt HOT RELIGHT. If engine does not relight and altitude permits, prepare to attempt a COLD RELIGHT, and follow the emergency procedures given in the check-

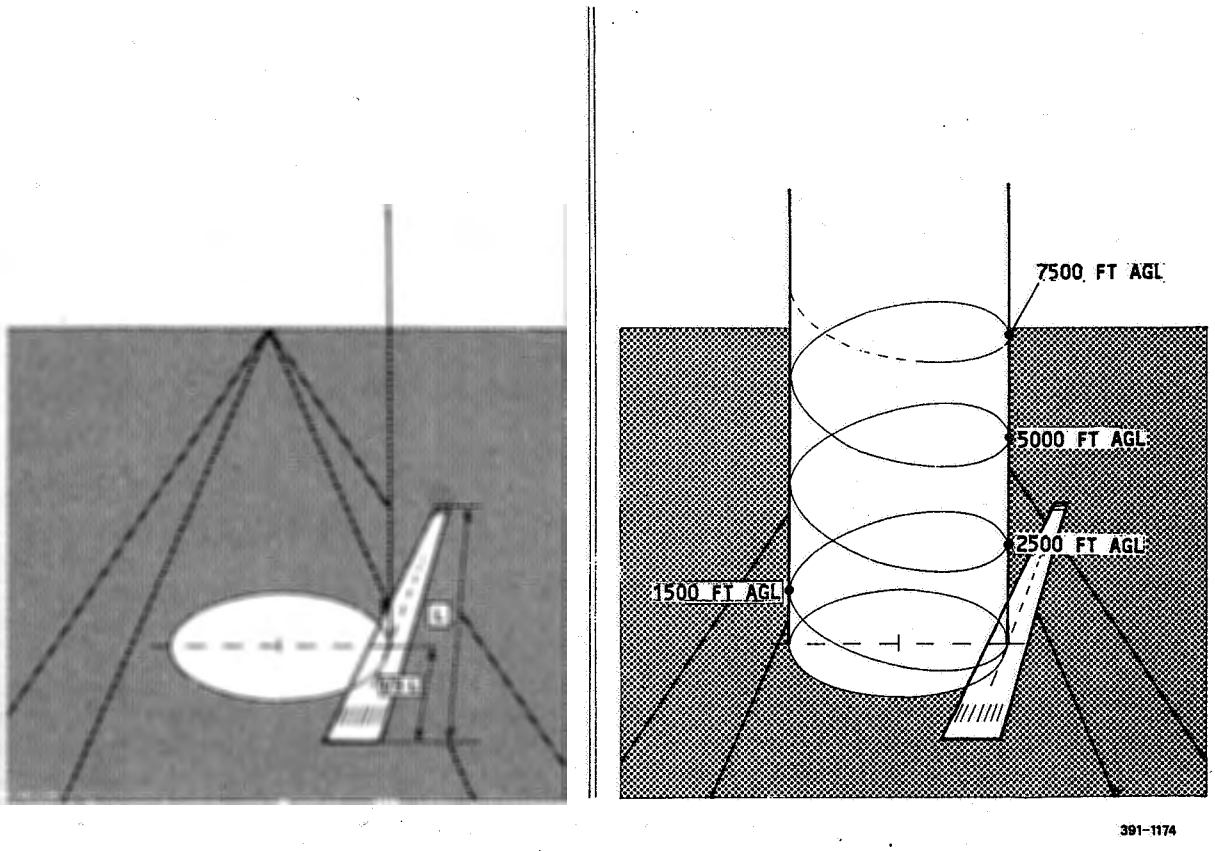
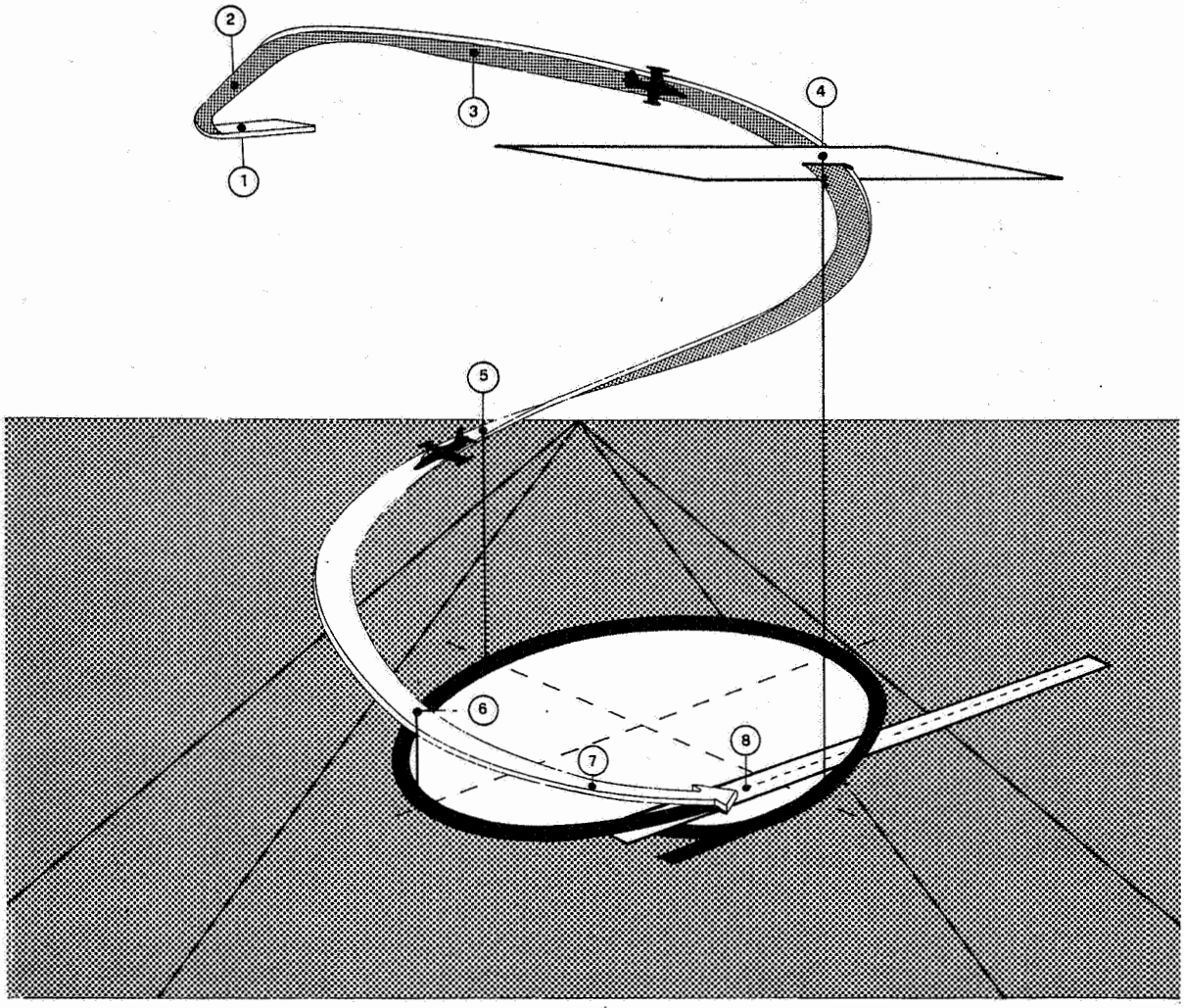


Figure 9-1. Forced Landing Pattern

list. If even the first cold relight or the subsequent relights (all accomplished at safe altitude) are not successful, decide whether to accomplish a power-off pattern or to eject, taking into consideration that the MB-339A glides a distance of approx. 11,5 NM from an altitude of 5000 ft (4,3 km every 1000 ft; or 2,3 NM every 1000 ft). The approximate (safe) rule to obtain the distance in NM that can be flown with power off is: "multiply by two the altitude in ft of the aircraft over the destination airfield".

Example: Glide started at 14000 ft (altimeter reading); airfield elevation 2000 ft; gliding distance (14 000 - 2000) x 2 = approx. 24 NM.



391-1175

1. LEVEL FLIGHT (IF "SIMULATED FORCED LANDING", 60% RPM AND SPEEDBRAKE OUT)
2. PITCH-UP TO ATTAIN 150 KIAS. HEAD TO CLOSEST AIRFIELD. ATTEMPT HOT RELIGHT WITHIN 30 SEC. PLAN GLIDE. CALL TOWER (RADIO). ATTEMPT COLD RELIGHTING
3. CHECKS FOR "FORCED LANDING", FUEL DUMP, FUEL SHUT OFF, ENGINE MASTER OFF
4. HIGH KEY POINT, 2500 FT AGL, 150 KIAS, LANDING GEAR DOWN AND CHECKS (IF SIMULATED: SPEEDBRAKE 28°, 60% RPM, 140 KIAS)
5. LOW KEY POINT, 1500 FT AGL, 140 KIAS, T/O FLAPS IF DESIRED
6. FINAL KEY POINT, 1000 FT AGL, 130 KIAS, FLAPS AS DESIRED
7. FINAL 115 KIAS PLUS CORRECTION (AOA .45)
8. TOUCHDOWN AT 1/3 RUNWAY

Figure 9-2. Forced Landing Procedure

(2) State the emergency and indicate your position and intentions.

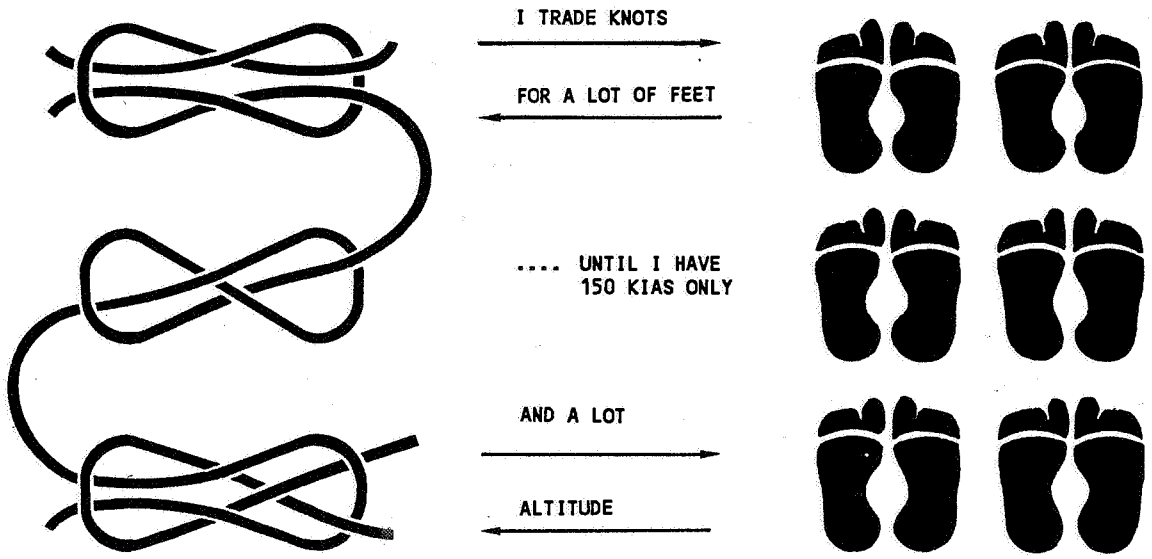
(3) If you decide for a power-off landing, enter the "forced landing pattern", and try to reach the most suitable key point.

(4) The forced landing pattern, consists of a helical path in the air whose projection on the ground is a circle tangent to the runway axis in its first third; the point of tangency should correspond to the touch--down point. In reality, to permit the aircraft position with respect to the ground to be better checked, the above point of tangency is considered to be slightly on the side of the runway (opposite to the approach direction). The said helical path climbs up from the touch-down point to reach a point called the "HIGH KEY POINT". A turn of the helical path corresponds to 2500 ft of altitude; thus every complete turn accomplished on the considered path from the ground up, leads to altitudes that are a multiple of 2500 ft (5000, 7500, 10 000, etc.).
The actual forced landing pattern starts at the high key point to be reached with the heading of the runway in use.
Turns flown at higher multiple altitudes will permit the HIGH KEY POINT to be reached precisely (correct position and parameters).

(5) At 150 KIAS and 2500 ft at the high key point, extend the landing gear and start a 30° banked turn allowing the airspeed to decrease down to 140 KIAS.

NOTE

This applies also to emergency lowering of the landing gear.



TRADE KNOTS FOR FEET

EXAMPLE: ENGINE FLAME-OUT AT FL 200 AT 250 KIAS; THE CLIMB TO GAIN ALTITUDE BY EXPENDING SPEED UNTIL 150 KIAS, ARE REACHED, BRINGS THE AIRCRAFT TO 22500 FT.
FROM THIS ALTITUDE, GLIDING DISTANCE INCREASES BY APPROX. 6 NM (FROM 46 NM TO 52 NM)

Figure 9-3. Immediate Action Further to Engine Flame-out

(6) After 180° of turn, reach the "SECOND KEY POINT" (LOW KEY POINT) at an altitude of 1500 ft above ground level; maintain 140 KIAS and move the flaps to T/O.

(7) The subsequent point to be reached is the "FINAL KEY POINT" (90° of turn prior to runway line-up) where you must check that you are flying at an airspeed of 120 KIAS and at an altitude of 800 to 1000 ft. Lowering of the flaps to DOWN depends on this altitude. At any rate the flaps must be moved down only if it appears to be possible to reach the runway at an airspeed not below 110 KIAS. If not so, fly final and land with flaps at T/O.
Wind: The wind is of great importance in the "forced landing pattern". In consideration of the particular shape of the pattern, the turn can be tightened, widened or even interrupted at any point to correct the track.

(8) It is remembered that the lower the aircraft IAS is, the more the wind affects the aircraft path.
It is essential that the TOWER (or OPS) advises the pilot obliged to perform a forced landing of the meteorological conditions, the wind direction and strength on the ground, and the runway in use with a message of this type:
"Report on high key point at North (or South) end of runway. Hold pattern turning to left (or right). On final almost head wind, slightly from the right, strength 25 kt".
This message is aimed at helping the pilot in emergency conditions by supplying him all data needed for landing in the clearest possible way.

(9) In case of head wind (with respect to the runway) delay the turn at the "HIGH KEY POINT" in accordance with the principle stating that, with head wind (with respect to the aircraft) the wing bank angle should be reduced with respect to the usual pattern bank angle of 30°, while with tail wind, it should be increased. As far as all the other conditions between the two above conditions are concerned, the turn shall be played with a wing bank angle suitable to contrast the wind (fig. 9-4).

(10) It is not always possible to follow the ideal pattern: it may occur that the initial altitude or the airspeed are not sufficient to reach the high key point at 2500 ft.
Remember that the forced landing pattern has been established to ensure successful landing provided the aircraft reaches at least the last key point in the established conditions; it therefore ensues that (if the available initial altitude or airspeed do not permit the high key point to be reached) it is possible to head towards the "LOW KEY POINT" (fig. 9-5, sheet 1), suitably delaying the landing gear extension. If doubts are still present, head to the "FINAL KEY POINT".

(11) In case of excessive altitude at the high key point, lower the landing gear earlier and fly straight in the runway direction until half of the excess altitude is lost, then start turning to reach the low key point (fig. 9-5, sheet 2).

(12) If the helical path of the forced landing pattern has been entered above 2500 ft and clouds partially obscure it, its direction can be inverted above the "HIGH KEY POINT" (at its upward projection); the normal turn conditions will be established again when reaching 2500 ft.

NOTE

- If, while turning, altitude is found to be different from the required one, it is suggested to tighten the descending turn (up to 60° of bank, if required) rather than widening the turn to loose altitude; this maneuver requiring a great skill and being able to prevent the at-

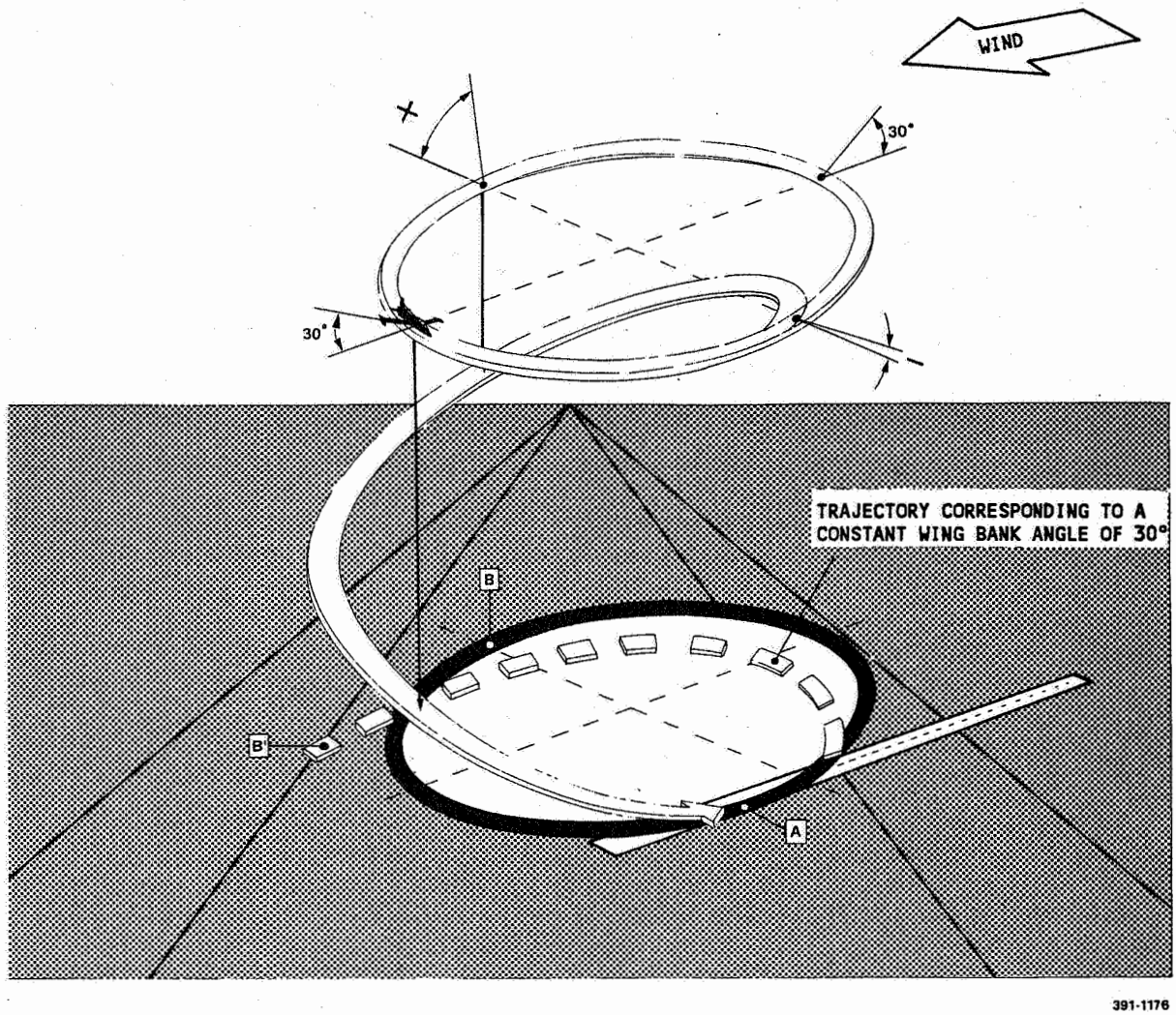


Figure 9-4. Correction of Wind Drift in Forced Landing

tainment of the other key points. It is therefore more convenient to extend the distance flown parallel to the runway.

- Banking the wings to a greater or lesser extent (according to the wind direction) must not be confused with the lengthening the ground track: the first action is accomplished to oppose the wind and NOT to modify the ground track.

(13) If overflying the runway at high altitude, when no engine relighting is possible, do not retard descent.
If for instance you are overhead the runway at 15000 ft, perform a quick dive (with speedbrake extended, if possible) up to 240 KIAS; with the appropriate lead, adjust the radius of turn and rate-of-descent to reach the high key point with the specified parameters. This is to be accomplished to avoid staying in an emergency condition for a long time with the possibility of further worsening the situation.

o. External Tanks Dumping

If this action is necessary, the external tanks must be dumped at a minimum altitude of 3000 ft AGL over an uninhabited area, possibly over the sea. For this purpose, refer to the regulations in force at the Air Base.

p. Jetttison of Underwing Tanks

If the underwing tanks are to be jettisoned in an emergency, remember that the MAXIMUM speed for release, possibly on the line of flight, is:

- 300 KIAS for full tanks
- 200 KIAS for empty tanks.

q. Emergency Descent (fig. 9-6)

(1) Many causes may compel the pilot to quickly leave high altitude and carry out an emergency descent.
It may occur that the pilot must go to landing as soon as possible, as in case of serious power plant failure. Some circumstances or malfunctions may arise (defective operation of the oxygen mask or oxygen system, hypoxia or hyperventilation symptoms, etc.) which oblige the pilot to descend to a lower altitude.

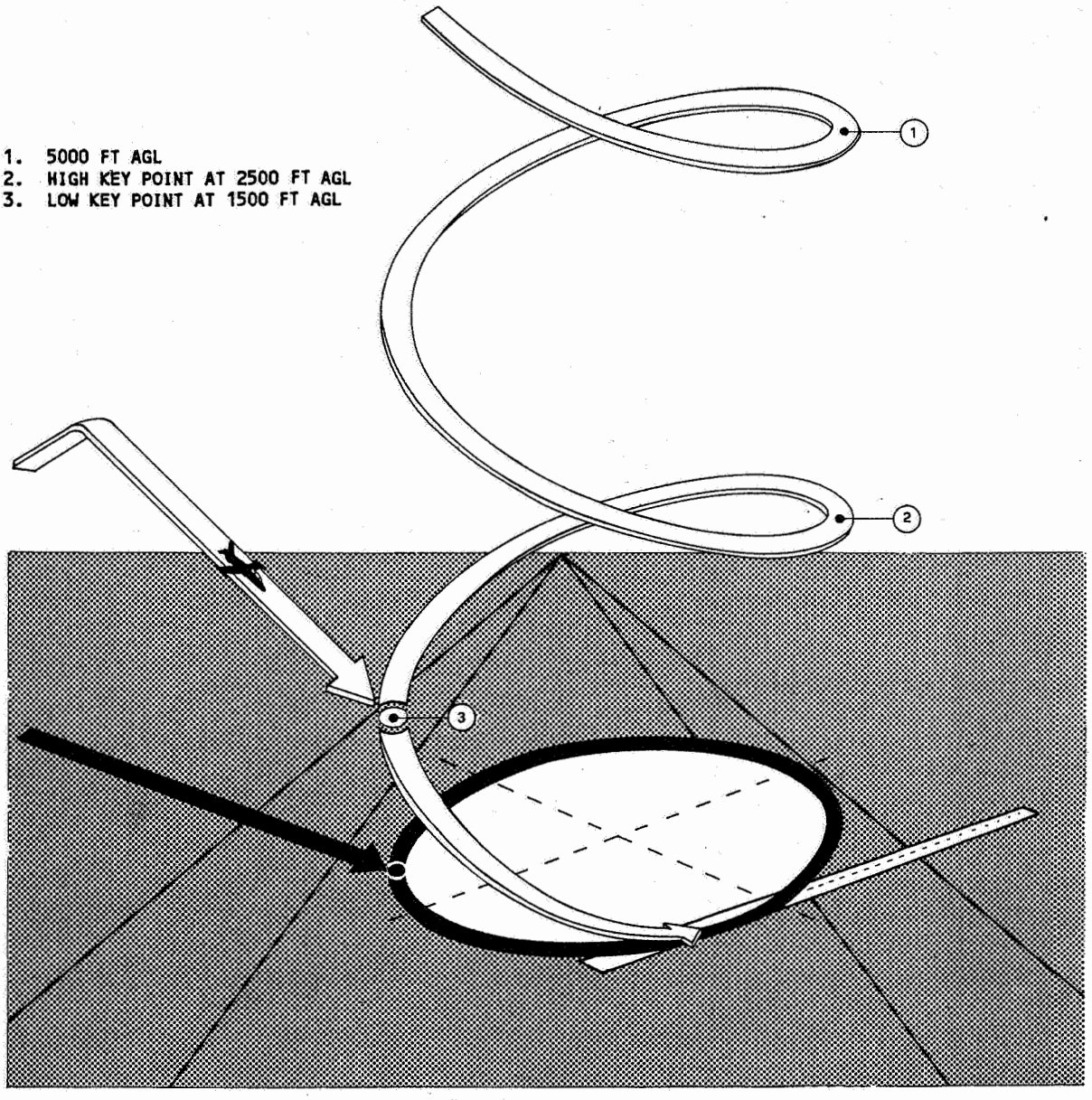


Figure 9-5. Changes to Forced Landing Pattern (Sheet 1 of 2)

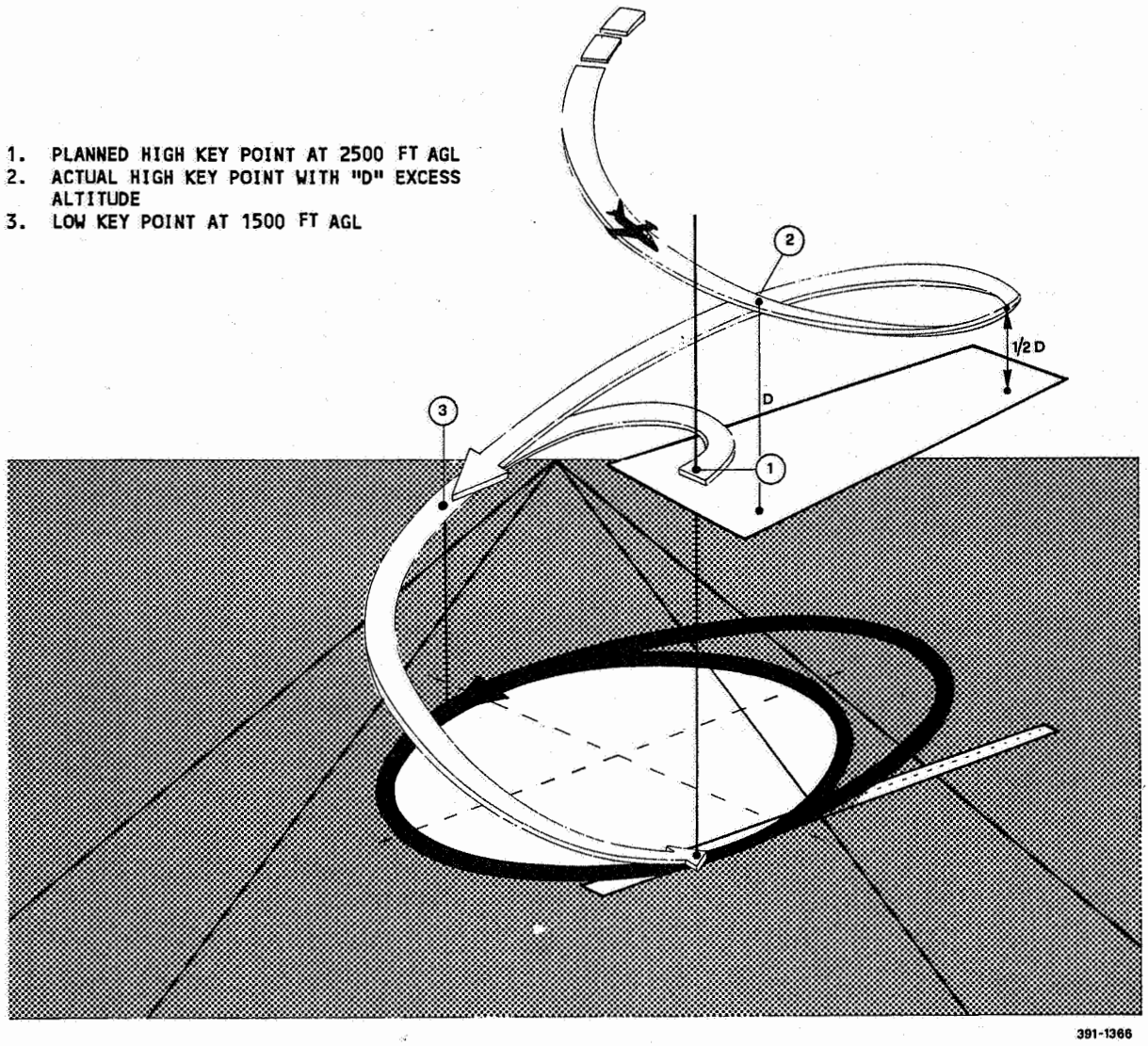


Figure 9-5. Changes to Forced Landing Pattern (Sheet 2 of 2)

(2) In all cases requiring a very fast descent, adopt the following procedure: start a descent with wing level, speedbrake out, rpm 75%, airspeed 280 KIAS. Set the "DEMIST" and "RAIN RMVL" switches to ON to ensure canopy demisting.

(3) As a general rule, the defects occurring in the aircraft require the pilot to declare emergency. It is advisable to notify the emergency conditions from high altitude, where radio communications are easier.

(4) The pilot may be obliged to accomplish an emergency descent also because of explosive decompression due to failure of the canopy or if the pressurization system. In these circumstances he must adopt different parameters. As a general rule, it is advisable to fly an as slow as possible descent, with level-offs, if required, at intermediate altitudes.

(5) During descent from high altitude, periodically check the altimeters (first altimeter in the front cockpit, then altimeter in the rear cockpit and cabin altimeter) to ensure you have not incurred reading errors.

r. Compressor Stall

See the FM, Section III. This is essentially an aerodynamic phenomenon affecting the compressor blades.
It consists of the separation of the airflow in a stage or a group of stages (STALL) or in all compressor stages (SURGE).

(1) In the first instance, there are only slight vibrations and rumbling, as in the case of very rough engine operation, and an abnormal JPT increase. In the second case, the stall is accompanied by one or more bangs, strong vibrations, a sudden and large JPT increase, and possibly by flame-out.
When surge is preceded by stall, the transition may be gradual or abrupt.

(2) The causes that may determine the compressor stall/surge are various, and are indicated in the FM, Section III.

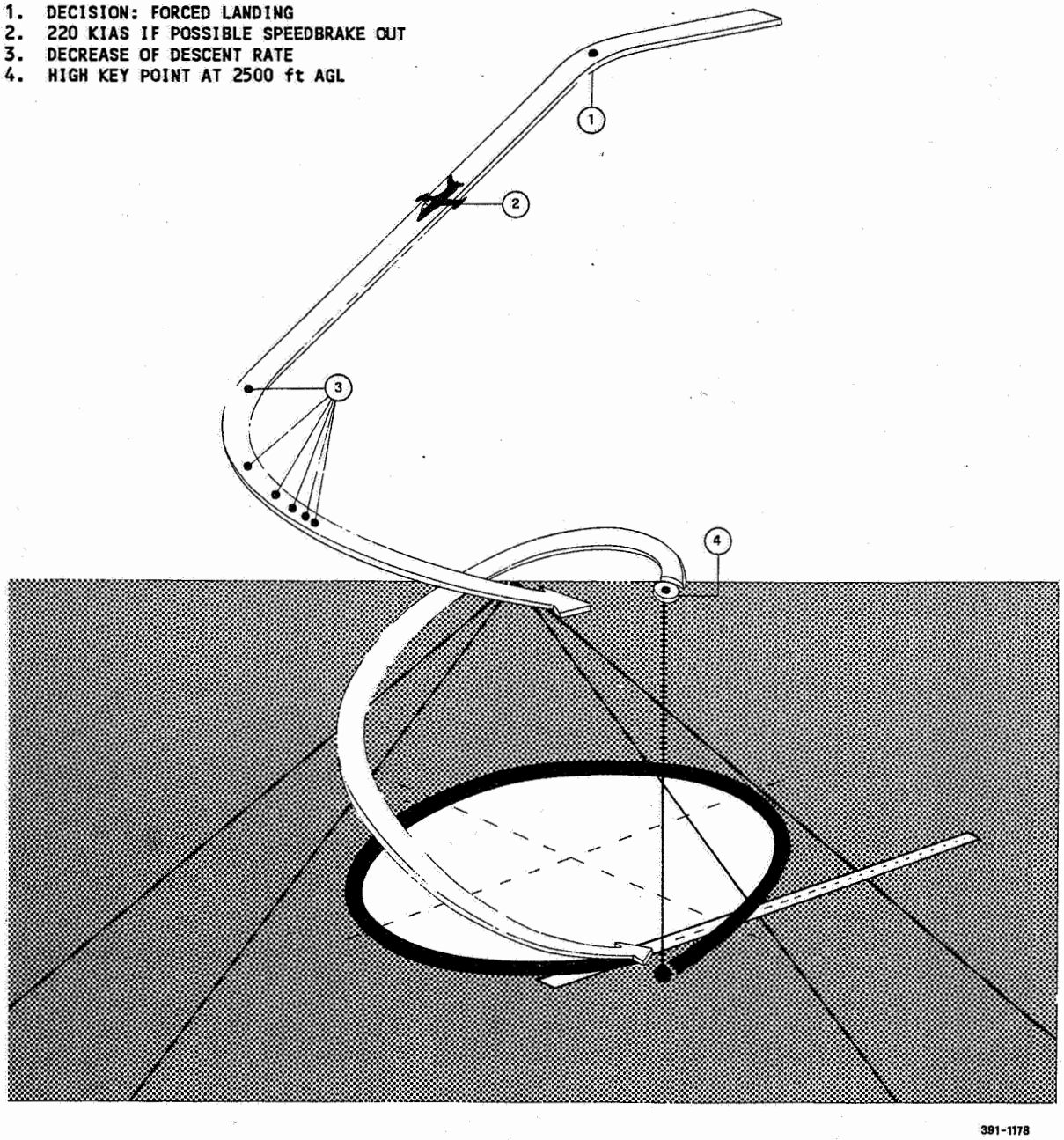


Figure 9-6. Steep Descent for Forced Landing

(3) As far as safety is concerned, a stall at altitude is generally not dangerous, even when followed by flame-out, since there is the possibility of attempting engine relight. Stall at low altitude, for instance during engine reopening on final, can be more critical.

WARNING

Relighting is not possible only in case of flame-out caused by BOV locked in closed position.

(4) The corrective actions are those indicated in the FM, that is:

(a) Immediately retard the throttle to IDLE.

(b) Lower the aircraft nose to leave the stall angle-of-attack and restore normal engine rpm and temperature.

(c) When the engine is back within the normal operating limits, slowly advance the throttle to attain the required minimum power setting.

(d) Go immediately to landing by accomplishing a precautionary or forced pattern and avoid any rapid throttle movement.

NOTE

- Stall of a single stage of blades may also remain undetected by the pilot.
- During recovery, if the temperature tends to exceed 700°, even with throttle at IDLE, retard the throttle to STOP and accomplish a normal engine relight, possibly at lower altitude.
- If the engine remains stalled even with throttle at IDLE and JPT high but below the limits (HANG-UP) dive to increase airspeed and await until the normal rpm and temperature are attained. At altitudes below 20 000 ft, recovery should occur at any indicated airspeed.

s. Precautionary Pattern

When the aircraft may be affected by a thrust decrease or a flame-out, the pilot must accomplish a precautionary pattern by proceeding as follows:

(1) Accomplish a radio call stating that you intend to fly a precautionary pattern. Indicate position and altitude.

(2) Do not touch the throttle, unless it is strictly necessary.

(3) Head to the nearest suitable airport, maintain 150 KIAS and gain altitude if possible.

(4) From the high key point, with landing gear and speedbrake extended, maintain 60% rpm.

(5) In the event of actual flame-out while flying the pattern, operate as instructed in para 2 p. "Forced Landing Pattern".

3. SIMULATED EMERGENCIES

a. General

Some in-flight emergency conditions are simulated for training purposes. Hereafter there are given the procedures as well as the parameters to simulate emergencies in the most realistic manner.

b. Simulated Forced Landing

(1) To accomplish this maneuver, the aircraft is brought to conditions of nearly complete lack of thrust, as follows:

(a) Power setting is reduced to 60% RPM, and the speedbrake is extended.

(b) At the high key point, after having lowered the landing gear and checked that the speedbrake is retracted to 28°, power is further reduced to 55% and the speedbrake is retracted.

(2) It is always a task of the pilot in command to bring the aircraft to the parameters applicable to simulation conditions.

(3) The sequence of operations for the pilot performing the simulated emergencies is the following:

(a) Trade airspeed for altitude and head the aircraft to the nearest airfield. Stabilize airspeed at 150 KIAS.

(b) State the simulated hot relight (within 30 seconds).

(c) State that you are planning to reach the most suitable airfield.

(d) Contact the TWR providing altitude and estimated position on ground with a radio call of this type: "Jumbo TWR, Lion 82, simulated 8000 ft. South-West of airfield".

(e) State the simulated cold relight.

(f) Report the TWR the first overflying of the airfield in accordance with the received instructions.

(g) Accomplish the other radio calls specified for the maneuver in progress ("HIGH KEY POINT", "LOW KEY POINT", "FINAL").

(h) If you intend to report at a key point different from the HIGH key point, advise the TOWER when starting the maneuver.

c. Simulated Failure of the Landing Gear Control

Operate as for an actual emergency (See the FM).
The landing gear retraction after a simulated emergency is obtained by pushing the "LG EMERG SEL" handle to full travel and moving the landing gear control lever to UP, maintaining airspeed below 175 KIAS until the retraction is complete and the lights are out.

d. Simulated Failure of the Flap Control

See "Flapless landing" at para 3 h. in Chapter VII.

e. Simulated Failure of the Aileron Servocontrol

- Move the "AIL SERVO" switch to OFF (Guard and lever up).
- Reduce power to attain an airspeed below 350 KIAS. Extend the speed-

brake, only if required, and retract it when IAS has stabilized.

f. Simulated Failure of the Brake System

After landing, with nosewheel in contact with the ground, apply brakes by using the "PARK & EMER BK" handle; adjust the braking action as required.
Bear in mind that the hydraulic pressure concurrently acts on both brakes. If the aircraft tends to enter a ground loop, discontinue braking, engage the steering, realign the aircraft, and reapply the brakes.

g. Rapid Descents Simulating Emergencies

Rapid descents may also be accomplished for training purposes. They are to be carried out in accordance with the procedures described in Chapter VII, para 1.d, by accomplishing wide turns reversing direction in order to clear the area below. No specific radio call is requested. Carry out the checks as instructed in Chapter VII, para 1a.

4. CONCURRENT EMERGENCIES

a. General

If several emergencies are concurrently or almost concurrently experienced, the pilot shall exploit his skill and the gained experience to take the appropriate corrective actions. Some concurrent emergency conditions are considered hereafter. It is however impossible to envisage all types of concurrent emergencies.

b. Engine Flameout

The most important sequence of emergency conditions to be considered is that initiated by engine flameout in flight.
Within a few seconds from engine flameout, the following conditions will be encountered:

- RPM below 23% RPM (12 to 18% RPM) and consequently:
- generator No. 1 and generator No. 2; OUT

- all loads connected to the primary bus, the secondary bus, the monitor bus and the armament bus, i.e., to quote only the most important ones: all radionavigation units, pitot head heating, anti-ice system, AHRS, AOA and fuel transfer systems will become inoperative.
Immediately engage the "BUS RESET" switch to connect the primary, secondary and armament busses to the essential bus. All electrical loads will return to operation, except for the heating system of the air intake lips and ducts.

c. Emergency for Complete Hydraulic Failure

Lack of hydraulic pressure due to the pump failure may not originate other emergencies provided the "AIL SERVO" switch is moved to OFF as soon as the hydraulic pressure drops below 150 bar (stabilized).
See the FM, Section III.
If the "AIL SERVO" switch is left engaged, the pressure will drop below 70 bar after a few minutes of flight; this could result in the need to extend the landing gear and brake by using the emergency hydraulic system.
If the pressure gauge of the main hydraulic system reads zero, this means that there is a leak of hydraulic fluid from the main system.

5. COMMAND TO ABANDON THE AIRCRAFT

The command may be given in flight or on the ground by the instructor or the Ground Officer.
The pilot who is flying solo and takes the decision to eject must comply with the procedures described in the FM, Section III.
Bear in mind that, in extreme conditions, the instructor may command his own ejection and the student's ejection in sequence (after 0,3 seconds) from the rear cockpit.
If the necessity of abandoning the aircraft is not immediate, the instructor must advise the student in advance and briefly summarize the actions to be taken for ejection and after ejection.
The pilot in the rear seat should normally eject first, immediately followed by the pilot in the front seat.
In case of very critical conditions, do not await the instructor's command: eject immediately.
The pre-flight briefing should always establish the actions to be taken in critical conditions when no interphone communication is possible.

6. COMPLETE ELECTRICAL FAILURE

This is a very serious emergency that is however extremely unlikely to occur, as the aircraft is fitted with two dc generators and two independent batteries; four concurrent failures would thus be necessary to remain without the possibility (even limited) of using the electrically operated controls and instruments.
A complete electrical failure however means that you cannot actuate any controls and systems except for the stick and rudder pedals, the engine throttle, and the ram air scoop.
All caution and warning lights will be inoperative, and so will all instruments, exception made for the Mach-airspeed indicator, the altimeter, the vertical velocity indicator, the airspeed indicator, the jet pipe temperature indicator and the stand-by compass.
The emergency attitude indicator will continue to operate for approx. two minutes after failure.
The trim tabs will not be serviceable. It will be possible to extend the landing gear only by use of the emergency handle, the speedbrake and flaps will be inoperative.
The radio communication, navigation and interphone systems will be inoperative. The flight can be continued only in VMC at altitudes below 13000 ft. The fuel will flow to the engine only by gravity.
In the event of engine flame-out, relight will not be possible.
The JPT limiter will be inoperative.
The oxygen flow will be normal, but no indication will be present on the blinker.
Seat height adjustment will be prevented, but all ejection devices will be serviceable.
Also the canopy transparency severance system will be operative.

7. INTERPHONE SYSTEM FAILURE

In the event of HOT MIC interphone system failure, turn to COLD MIC by pushing the "INT" switch, then press transmission push-button on the control stick to obtain interphone communication. (See FM, Section I).
If communication is not obtained, bear in mind that the pilot in command becomes automatically the one who is able to communicate with the traffic control activities.
If both pilots are in the same conditions; viz. capable/uncapable of communicating with the tower, the pilot in command is the instructor.

The instructor may however leave the controls (but not the responsibility of the flight) to the student, at his discretion.
Shaking the control stick will draw the student's attention. The student will nod his head to reply YES or move it to reply NO to the directions of the instructor, who will see him through the rear vision mirror.
The instructor, by moving the right hand at the helmet level with the forefinger pointing forward will give the command "You take the control"; while with the forefinger pointing towards his head will give the command "I take the control".

8. AIRSPEED INDICATOR AND/OR ALTIMETER FAILURE

The systems that operate the pitot-static instruments of the two pilots are fully independent.
In dual flights, failure of a pneumatic instrument can be checked by requesting the other pilot to read the concerned parameters in a loud voice (for instance every 10 seconds).
In case of solo flight, failure of the airspeed indicator is not an emergency for the MB-339A aircraft since flight, approach and landing can be performed on the AOA indicator.
To this purpose, it is suggested to accomplish training in the use of the AOA indicator only.
The altimeter failure above 8000 ft requires cabin depressurization and reading of the cabin altimeter.
(Refer to the "Instrument Flying and Navigation Manual"). The cabin altimeter is affected by errors of less than (minus) two hundreds feet with respect to the QNE.
When flying at altitudes below 8000 ft, cabin depressurization is not necessary.

9. POST-LANDING ASSISTANCE FOR EMERGENCIES

If the pilot deems it necessary, he can request (via TWR) the assistance of the fire brigade and the ground emergency personnel as a precaution; they should approach the aircraft on the runway when it stops.
Bear in mind that, from the moment the ground personnel approaches the aircraft, the pilot must refrain from operating the speedbrake, flaps, etc.
The pilot, who has shut-down the engine as soon as possible, will keep both hands raised in front of his head to advise the ground personnel that they may closely inspect the aircraft.

10. LOSS OF ORIENTATION

If the pilot is unable to establish, visually or by use of the radionavigation systems, his geographical position in any phase of the flight, he must:

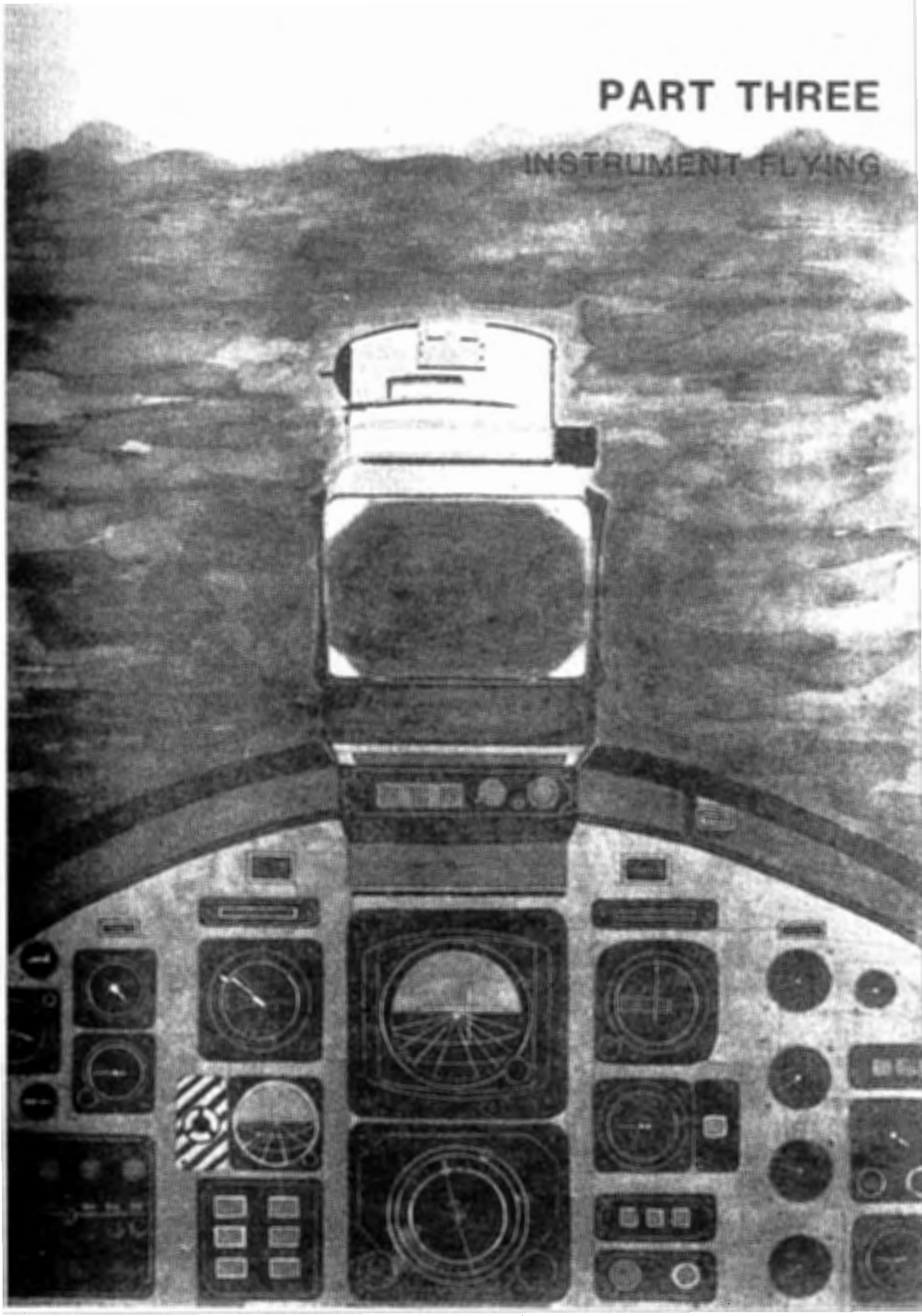
(1) Maintain the position on the ground, fly a spiral to attain 10 000 ft (if fuel permits); at the same time look for a sure landmark and recognize it on the map.

(2) If disorientation persits, select the appropriate frequency (approach frequency) to request a QDM bearing and head the aircraft towards the station (if possible, try to obtain VOR bearings as an alternate to TACAN bearing).

Comply with the instructions received from the ground station operator.

(3) If no radio contact is obtained with the ground station, contact RADAR and position the IFF-SIF to 3-A/55, or as requested by the ground operator.

(4) If a complete radio failure exists, place the IFF/SIF to EMERG and FLY TRIANGULAR PATTERNS TO LEFT by flying legs of 1 minute each connected by 120° turns. In case of radio failure to the transmitter only, FLY TRIANGULAR PATTERNS TO RIGHT.
See also Chap. XI, para 2.f.


PART THREE
INSTRUMENT FLYING

PART THREE - CHAPTER X

BASIC INSTRUMENT FLYING

TABLE OF CONTENTS

Title	Page
SECTION A - INSTRUMENT FLYING GENERAL	
Introduction	10A-1
Sensory Impressions in Flight	10A-2
Attitude Instruments	10A-17
Attitude Control Technique	10A-25
Correction Technique	10A-28
SECTION B - BASIC INSTRUMENT FLYING	
Ground Maneuvers	10B-1
General Information on Instrument Flying	10B-1
Instrument Take-off	10B-1
Instrument Climb	10B-3
Instrument Level-off and Instrument Straight and Level Flight	10B-4
Instrument Turns	10B-9
Speed Changes	10B-15
Slow Instrument Flight	10B-17
Instrument Descents and Level-off After Descent	10B-19
Climbs and Descents at Constant Vertical Speed	10B-23
SECTION C - CONFIDENCE MANEUVERS	
Vertical "S"	10C-1
Recovery from Slow Instrument Flying	10C-4
Unusual Attitudes	10C-5
Flight with Incomplete Instrument Panel	10C-11
Radio Aided Instrument Flying	10C-14

PART THREE - CHAPTER X

SECTION A - INSTRUMENT FLYING GENERAL

1. INTRODUCTION

a. General

Instrument flight is a type of flight accomplished on the airborne instruments.
These indications permit the aircraft to be piloted without outside visual reference.
Piloting on the instruments requires an adequate level of specific training providing for a quick and safe understanding of the correlated readings of several instruments and consequently a precise and coordinated action on the flight controls to fly the aircraft with the desired attitude, altitude, heading and airspeed parameters.
For the above reason, the instrument flying is included in the training program when the pilot has already become familiar with the airborne instruments and controls through visual flying training.
During the training phase, to reproduce the no visibility conditions, a hood is fitted which prevents any outside visibility.
Instrument flying is divided into:

- Basic instrument flying (included in this chapter)

NOTE

It is indispensable that also the FM and publication PI AD-03-39A be read.

- Radio aided instrument flying (included in publication PI AD-03-39A "Instrument Flying and Navigation Manual").

b. Rules

Except for special authorization for operational flights granted time by time by the concerned authorities, the military aircraft are requested to comply with the AIP - RAC 1-6 "General Air Traffic Rules" (Annex 2 ICAO - Chapter 4).

2. SENSORY IMPRESSIONS IN FLIGHT

The instructions, recommendations and comments contained in this para apply to actual instrument flying, blind flying, night flying and flying under conditions of poor visibility.

a. General

During flight, illusions result from false sensory impressions created by inflight forces acting upon the organs of equilibrium and balance and the muscles in contact with the aircraft; the brain is unable to distinguish these impressions from the true sensations experienced when the body is static or in rectilinear and uniform motion.

All pilots are susceptible to sensory illusions which may suddenly and markedly affect their ability to accurately determine their flight attitude.
During visual flight, the sense of sight is used to determine the relationship between the aircraft attitude and the earth surface.
During instrument flight, when the aircraft attitude must be controlled by reference to the flight instruments, conflicts may evolve which cause the supporting senses to disagree with the sense of sight.
When a pilot cannot accurately determine the location of the surface of the earth, he is said to be suffering from spatial disorientation also commonly called "pilot's vertigo". It is important to remember that sensory conflicts will occur regardless of a pilot's instrument experience or proficiency.
However the influence and result of the illusions will depend partly on a pilot's experience and training.
By recognizing that the inputs from the supporting senses are false or not reliable, a pilot may suppress or ultimately learn to disregard these inputs to prevent conflict with what he sees on the aircraft instruments.

b. Organs of Equilibrium (fig. 10-1)

Three of our sensory systems are especially important for maintaining the equilibrium and balance.
These sensory systems function adequately for the normal earthbound activites such as walking, running, jumping, falling, etc. but when the man is in an aircraft subjected to an environment without visual references, the organs of equilibrium may induce errors.
Such errors cause illusions which may result in spatial disorientation and vertigo.

The sensory systems are:

(1) The vestibular system (fig. 10-2)

(a) Semicircular canals: the semicircular canals are filled with a fluid which moves relative to the canal walls when angular accelerations are applied to the head. The movement of the fluid causes bending of the hair filaments in the canals, resulting in nerve impulses being sent to the brain. The pilot's interpretation is that rotary motion is occurring. The three semicircular canals on each side are positioned at right angles to each other so that angular accelerations in any spatial plane can be detected; i.e. yaw, roll, pitch. Since the response charac-

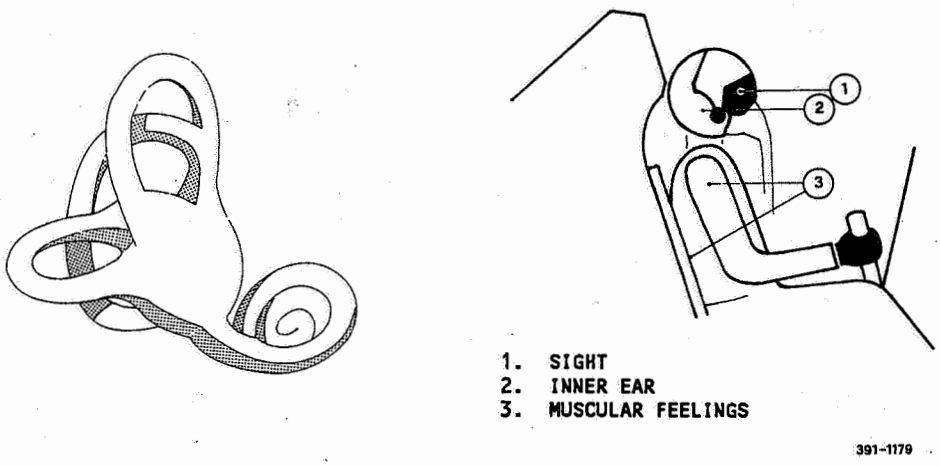
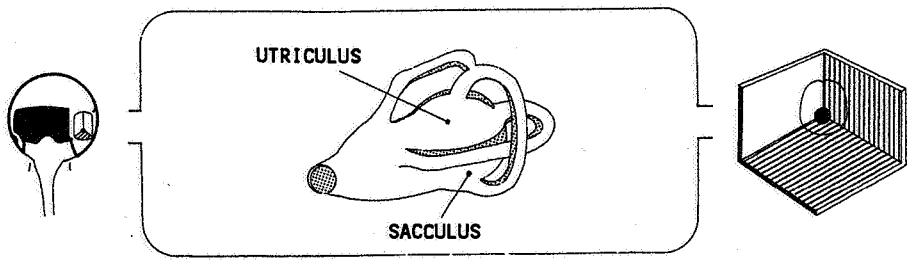


Figure 10-1. Senses Used to Maintain Equilibrium and Orientation



THE STATIC EQUILIBRIUM ORGAN IS LOCATED INSIDE THE UTRICULUS-SACCULUS AND CONSISTS OF A BED OF VERTICAL HAIR FILAMENTS COVERING THE SACCULUS INTERIOR; ON TOP OF THE HAIR FILAMENTS ARE TINY CRYSTALS OF CALCIUM SULPHATE.
THE CRYSTAL WEIGHT IS APPLIED ON THE HAIR FILAMENTS AND MAKES THE HAIR FILAMENTS BEND WHEN THE HEAD IS INCLINED WITH RESPECT TO THE APPARENT VERTICAL OR, LINE OF INERTIA FORCES. THE HAIR FILAMENTS TRANSMIT THE SENSATION OF THE UPRIGHT POSITION TO THE BRAIN. THE INNER EAR IS LOCATED INSIDE THE SKULL IN THE POSITION APPROXIMATELY INDICATED IN THE DRAWING. IT CONSISTS OF AN UTRICULUS, A SACCULUS AND THREE SEMI-CIRCULAR CANALS POSITIONED AT RIGHT ANGLES TO EACH OTHER.
EACH SEMI-CIRCULAR CANAL IS FILLED WITH A FLUID LIQUID CALLED ENDOLYMPHATIC FLUID. AT THE END OF THE CANAL, SMALL SENSITIVE HAIR FILAMENTS PROTRUDE INSIDE THE CANAL, WHICH, WHEN BENT BY THE MOVEMENT OF THE FLUID IN THE CANAL, GIVE THE BRAIN THE TURNING SENSATIONS IN THE THREE ORTHOGONAL PLANES.
THE FLUID MOVES RELATIVE TO THE CANAL WALLS WHEN ANGULAR ACCELERATIONS ARE APPLIED TO THE HEAD.
THE MOVEMENT OF THE FLUID IN THE CANALS RESULTS IN NERVE IMPULSES BEING SENT TO THE BRAIN.
THE PILOT INTERPRETATION IS THAT ROTARY MOTION IS OCCURRING.

Figure 10-2. Mechanism of the Inner Ear (Sheet 1 of 2)

teristics of the semicircular canal system are specific for ground-based operations, perceptual errors may be induced in flight because:

(b) A very small or very short-lived angular acceleration may not be perceived.

(c) The patterns of acceleration experienced in flight are quite different from those experienced on the ground, thus the response of the canals gives erroneous information.

(d) Otolith organs: If these organs are subjected to linear or gravitational accelerations, the hair cell filaments penetrating the otolith membrane bend.
When the filaments are bent, nerve impulses travel along the vestibular nerve to the brain, providing information relating head position to true vertical (the direction of the pull of gravity). During flight, inertial forces are combined with the force of gravity. The direction of this combined or resultant force, which acts upon the otolith membrane is almost never the direction of the true vertical. In fact, if the brain monitors the positions of the otolithic membranes, and determines from them which way is "down", the brain will be deceived a large portion of the time in flight.

(2) Proprioceptive system (fig. 10-3). The proprioceptive sensors which are of major importance in equilibrium, are those that respond to pressure and stretch. They are buried in many body structures, including the skin, joints and muscles; and the sensations they elicit when stimulated are the pressing feelings that a person experiences when he sits, or the sensations which enable him to know the position of his arms, legs and body. This system is the so-called "seat of the pants" (fig. 10-4 and 10-5) sense referred to in flying because some pilots believed they could determine which way was down by analyzing which portions of their bodies were subjected to the greatest amount of pressure.

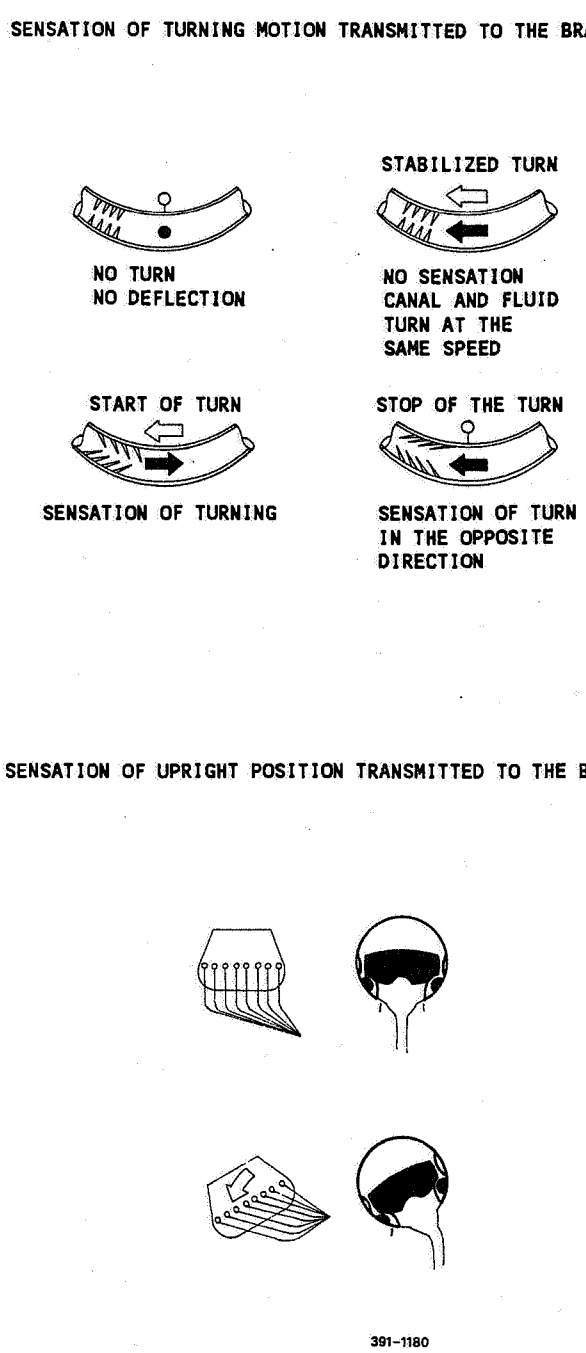


Figure 10-2. Mechanism of the Inner Ear (Sheet 2 of 2)

Since neither the ear nor the "seat of the pants" sense makes it possible for the pilot to determine the aircraft attitude, the pilot must only rely on visual references (external or instrument) for the aircraft attitude.

(3) Visual system. It is the only sense which provides reliable indications in any flight attitude (fig. 10-6).
By experience the pilot learns the meaning of the correlation between the horizon and the cabin coaming, and then but without too many difficulties, of correlation between the ADI earth sphere and miniature aircraft.
The observation of these reciprocal positions makes it possible for the pilot to remain oriented, even under conditions which would cause illusions if only the vestibular and "seat of the pants" sensory systems were monitored.

c. Spatial Disorientation

(1) Mechanisms of the illusions

(a) Graveyard spin (fig. 10-7). When the semicircular canals are stimulated by the angular acceleration produced by the spin entry, the pilot's first impression is accurate; that is, he perceives a spin. After about 10 to 20 seconds the fluid in the canals reaches a constant speed and the sensing mechanism returns to the resting position. Thereupon, the sensation of spinning is replaced by one of no-rotary motion despite the fact the spin continues. If the spin is then terminated, an angular deceleration is produced which acts upon the semicircular canals to cause a sensation of spinning in the opposite direction. Suffering from the illusion of spinning in the opposite direction, the pilot may try to correct for his false impression by putting the aircraft back into the original spin.

(b) Graveyard spiral. This maneuver is similar to the graveyard spin except the aircraft is in a descending turn rather than a stalled condition. The constant rate of turn causes the pilot to lose the sensation of turning after a period of time.
The pilot, noting the loss of altitude, may pull back on the stick (or perhaps add power) in an attempt to gain back the lost altitude. Unless he has first corrected the bank attitude, such actions can only serve to tighten a downward spiral.
Once the spiral has been established, the pilot will suffer the illusion of turning in the opposite direction after he stops the turning motion of the aircraft. Under these circumstances, an inexperienced pilot may take the wrong corrective action which will result in reestablishment of the spiral with fatal results.

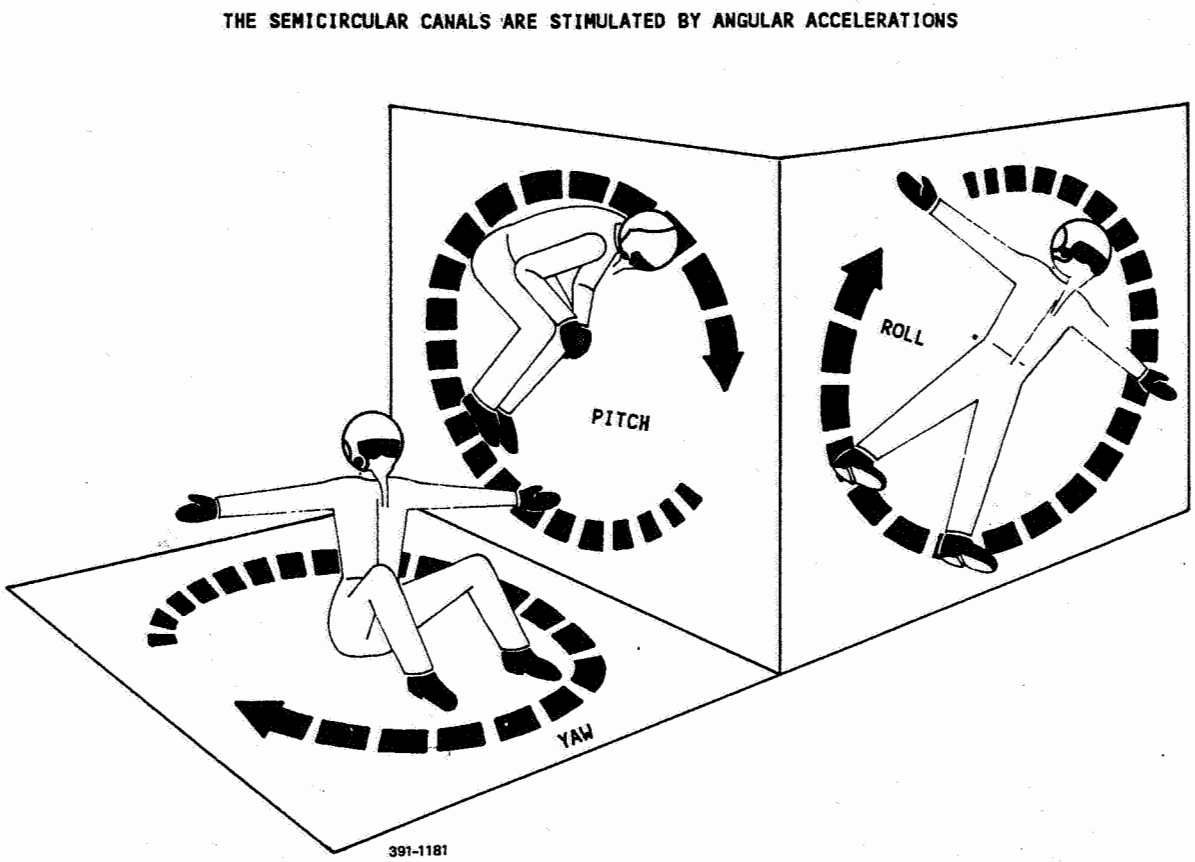
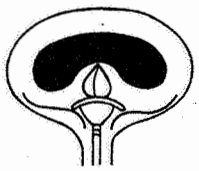


Figure 10-3. Sensory Impressions Through the Inner Ear (Sheet 1 of 2)

SEMICIRCULAR CANALS
ILLUSION OF ROTARY MOVEMENT

THE SEMICIRCULAR CANALS ARE STIMULATED BY ANGULAR ACCELERATIONS, VIA PITCH, ROLL AND YAW



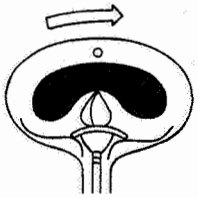
TRUE SENSATION

NO TURN

TRUE SENSATION

ACCELERATING TURN IN CLOCKWISE DIRECTION.
SENSATION OF TURNING CLOCKWISE

FALSE SENSATION



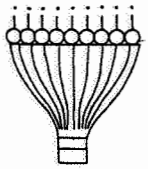
PROLONGED CONSTANT TURN IN CONSTANT TURN IN CLOCKWISE DIRECTION.
NO SENSATION OF TURNING

FALSE SENSATION

DECELERATING TURN IN CLOCKWISE DIRECTION, THEN TURN STOPS.
SENSATION OF TURNING IN CLOCKWISE DIRECTION

OTOLITH ORGANS
ILLUSION OF UPRIGHT POSITION

THE OTOLITH ORGANS ARE STIMULATED BY GRAVITY AND LINEAR ACCELERATIONS

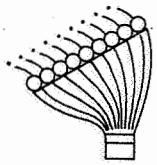


TRUE SENSATION

UPRIGHT OR LEVEL FLIGHT

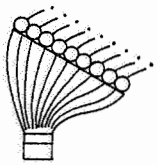
TRUE SENSATION

TILT FORWARD

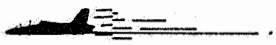


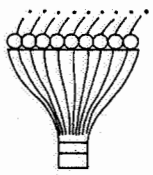
TRUE SENSATION

TILT BACKWARD



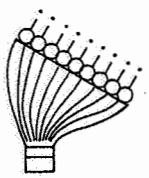
FORWARD ACCELERATION IN LEVEL FLIGHT. SENSATION OF TILTING BACKWARD

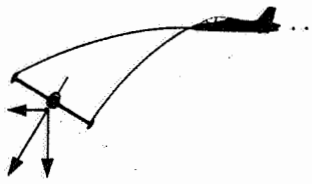




FALSE SENSATION

CENTRIPETAL ACCELERATION, CORRECT TURN. SENSATION OF UPRIGHT





FALSE SENSATION

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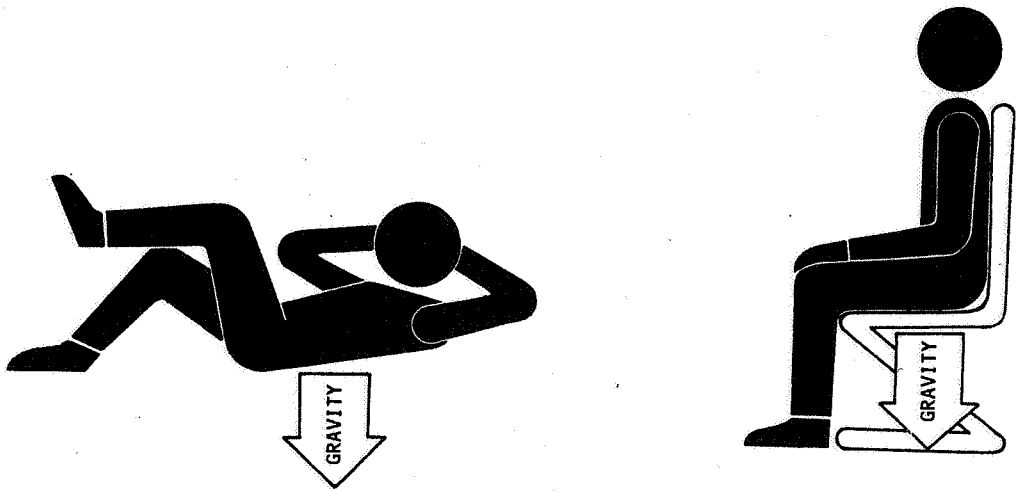
Figure 10-3. Vestibulo Sensation Through Inner Ear (Sheet 2 of 2)

ON THE GROUND: WHILE WE ARE IN CONTACT WITH THE EARTH, THE PULL OF GRAVITY SQUEERES THE PRESSURE SENSORS IN VARIOUS PORTIONS OF THE BODY, THUS TELLING US IN WHICH DIRECTION THE EARTH LIES



IN FLIGHT: WHILE IN FLIGHT, CENTRIFUGAL FORCES COMBINE WITH THE PULL OF GRAVITY, RESULTING IN G-FORCES WHICH MAKE THE SEAT-OF-PANTS SENSE COMPLETELY UNRELIABLE AS AN ATTITUDE INDICATOR

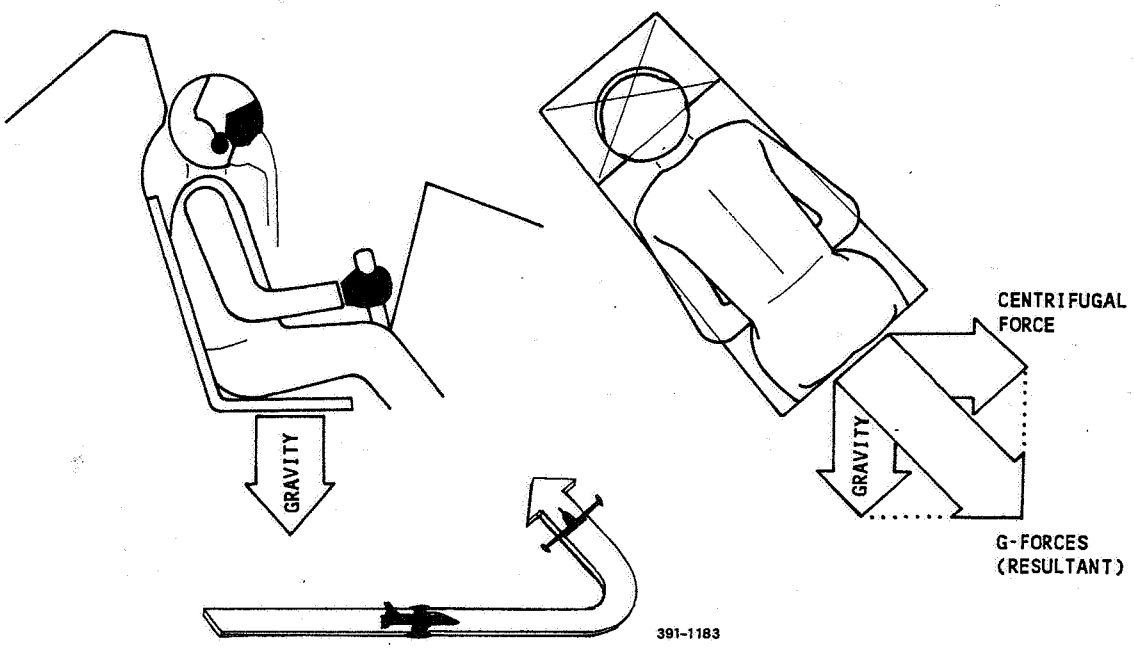
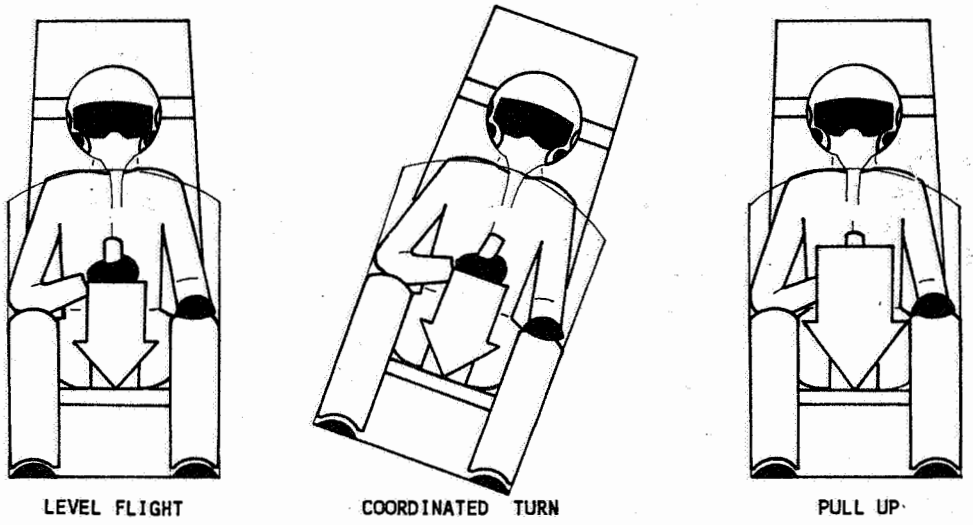


Figure 10-4. Somato Sensory System - "Seat of the Pants" Sense

LEVEL FLIGHT, COORDINATED TURN AND PULL UP GIVE THE SAME SENSATION: THE PILOT FEELS UPRIGHT ON SEAT



SKID, SIDESLIP AND UNCOORDINATED TURN GIVE THE SAME SENSATION: THE PILOT FEELS FORCED SIDEHANDS

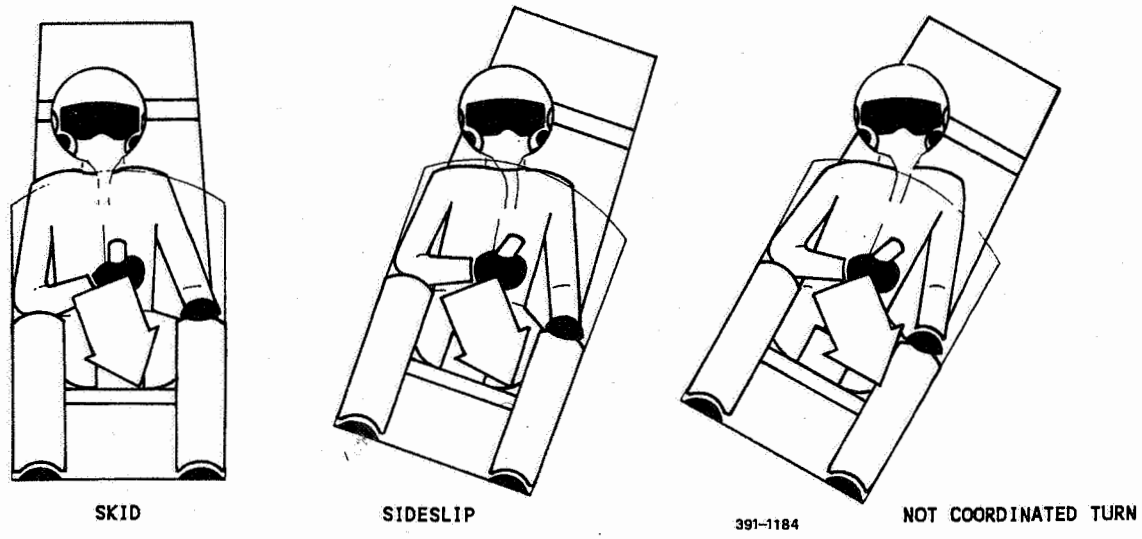


Figure 10-5. Somato Sensory System

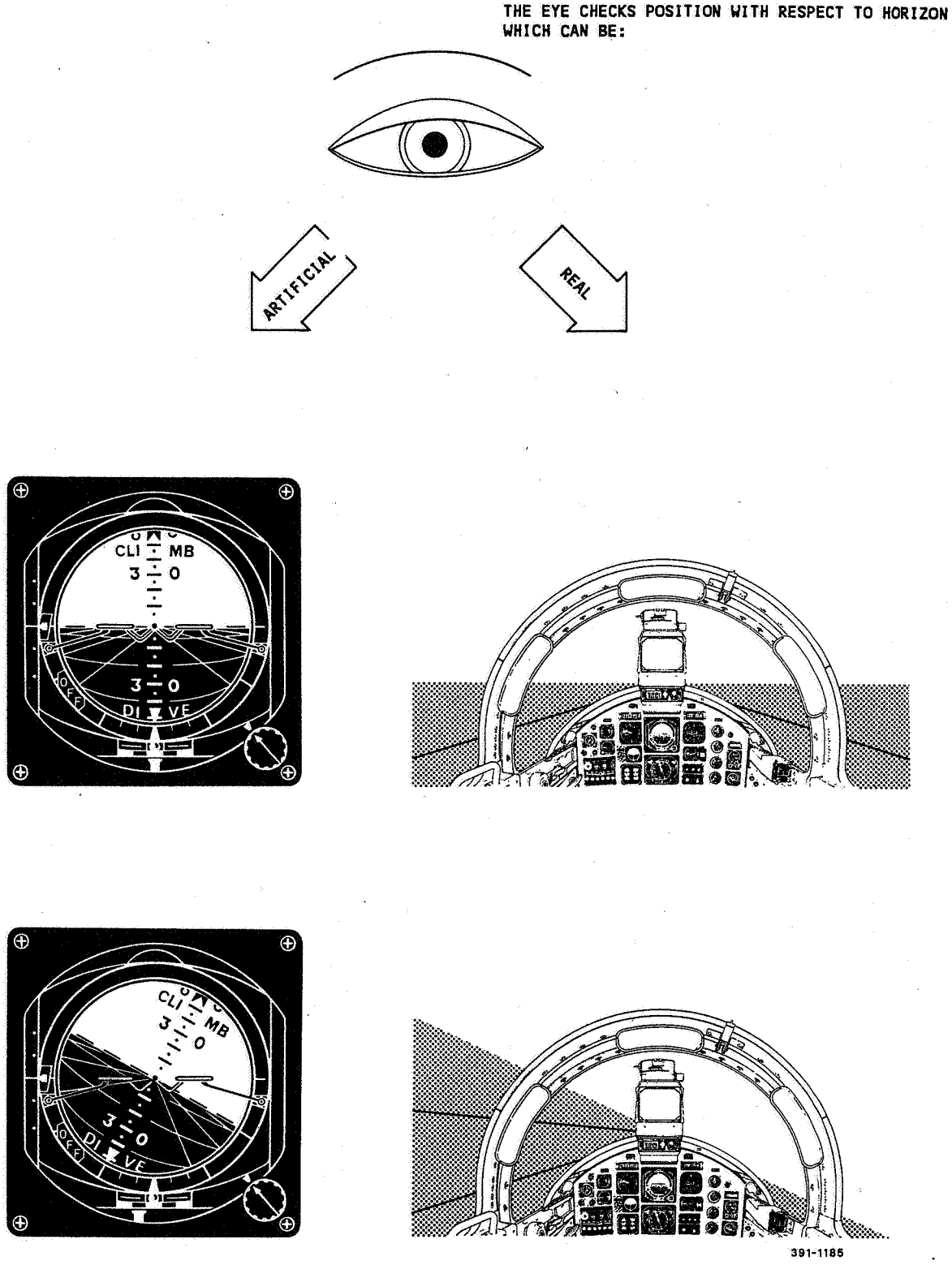


Figure 10-6. Sight is Used to Maintain Attitude

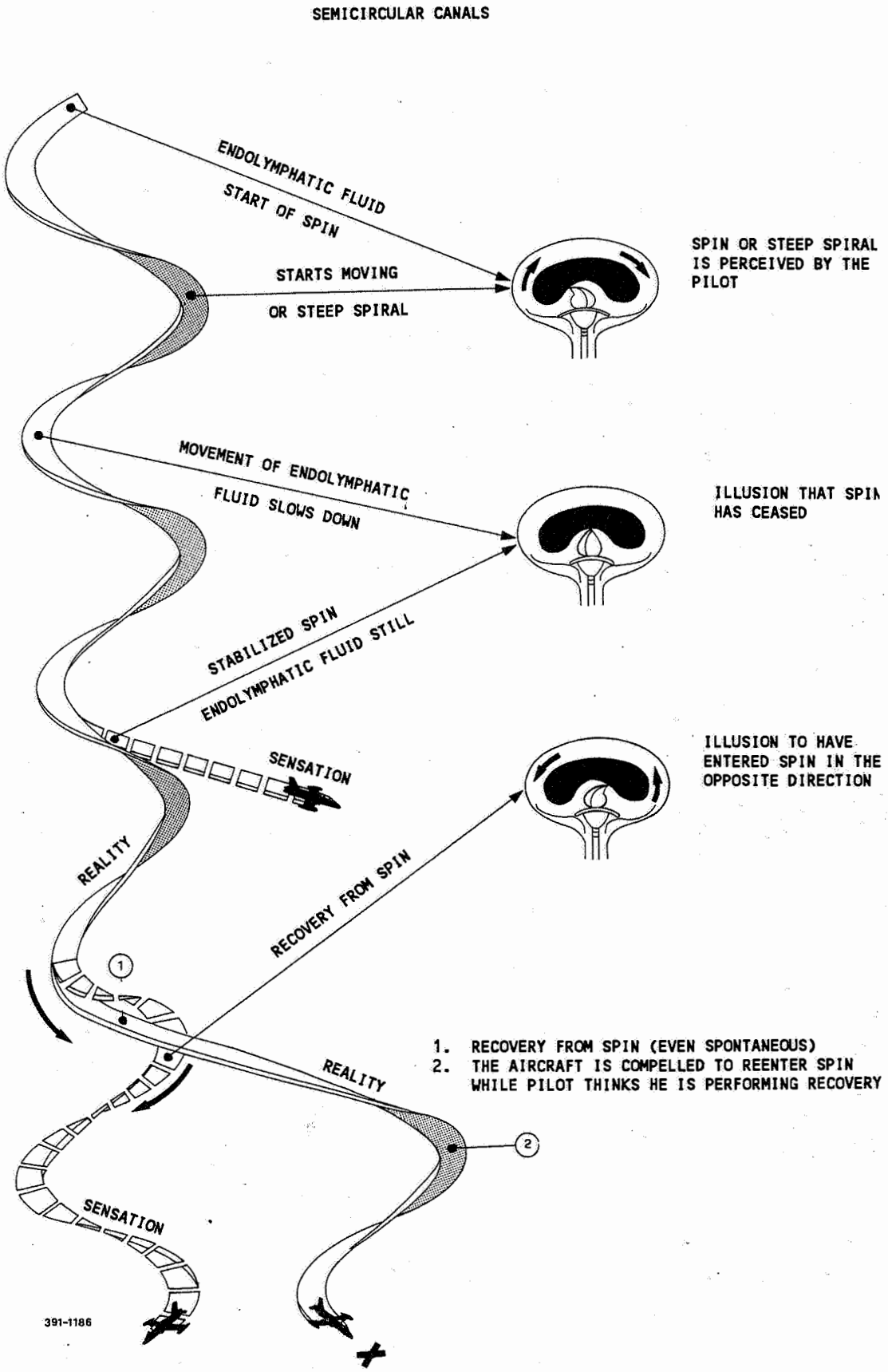


Figure 10-7. The "Graveyard Spin"

With crude realism Americans call "graveyard spin" the spin or spiral which brings directly to the graveyard.
By basing only on the sensory impressions, the pilot is unable to recover from the unusual attitude and .... dies.

(c) Coriolis illusion (fig. 10-8). When the body is in a prolonged turn, the fluid in those canals that were stimulated by the onset of the turn eventually comes up to speed with the canal walls. If the head is then tipped, the angular momentum of the fluid causes it to move again relative to the canal walls. The resulting sensation is one of rotation in the plane of the new position of the canal even though no actual motion has occurred in that plane. Thus abrupt head movements may cause the pilot to perceive maneuvers which he is not actually doing. If the pilot tries to correct for his illusion, he may put the aircraft in a very dangerous attitude. The Coriolis illusion is probably the most deadly of all the illusions because of its overwhelming sensations and because it usually occurs during maneuvers that normally take place relatively close to the ground.

(d) The leans. This is the most common vestibular illusion and is caused by banking (or rolling) the aircraft. After the pilot has a false impression of the true vertical, in a prolonged turn the semicircular canals may perceive a roll to wings level as a turn in the opposite direction. This causes the pilot to lean in an attempt to assume what he thinks is a true vertical posture.
If the pilot establishes a very subtle roll in a direction which does not stimulate the vestibular apparatus and then rolls rapidly to level flight, he may retain the false impression of only having rolled in the opposite direction. The pilot may fly adequately in spite of this illusion, although he may lean to assume a false vertical posture.

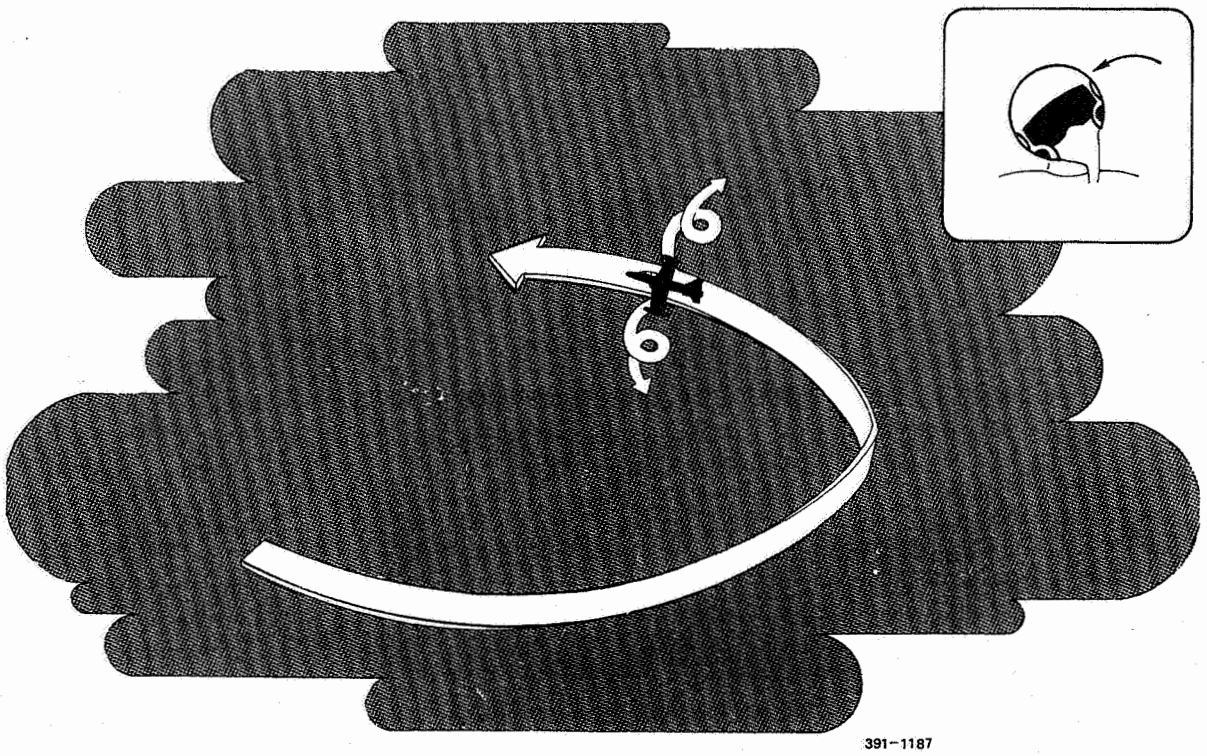


Figure 10-8. Coriolis Illusion

(e) Somatogyral illusion. This illusion creates the false sensation of rotation when the semicircular canals are abnormally stimulated by angular acceleration. Such an illusion occurs during the graveyard spin, the graveyard spiral, and other turning maneuvers. A somatogyral illusion may be associated with the Coriolis illusion. Under similar conditions of semicircular canal stimulation by angular acceleration, uncontrollable eye movement (nystagmus) may occur resulting in loss of effective vision due to inability to focus. Under these conditions the duration of the nystagmus is normally between 30 and 40 seconds after the stimulation stops.

(f) Somatogravic illusion (fig. 10-9). This illusion creates the sensation of change of attitude when the otolith organs are abnormally stimulated by linear acceleration. Such an illusion can occur when an aircraft accelerates forward while in level flight and gives the pilot the sensation of being in a nose-up attitude. A similar illusion of nose--high pitch may occur as a result of takeoff or missed approach acceleration. If the pilot was to correct for this illusion during climb-out, he might dive the aircraft into the ground. The opposite illusion of nose--down attitude may occur as a result of deceleration. If the pilot was to correct for the illusion of nose-low pitch caused by deceleration on final approach, his corrective action might result in a low altitude stall.

Although the somatogravic illusion is of greatest magnitude in high-performance aircraft, it may occur in all aircraft.

The maximum effect of the illusion normally occurs 30 to 60 seconds after onset of the linear acceleration (stimulus), but a substantial part of the illusion may occur within a few seconds after the stimulus.

The illusion remains constant during constant stimulus, and ceases immediately on cessation of the stimulus. It is possible to really overcome the illusion by giving attention to distinct, valid external visual references or to flight attitude instruments.

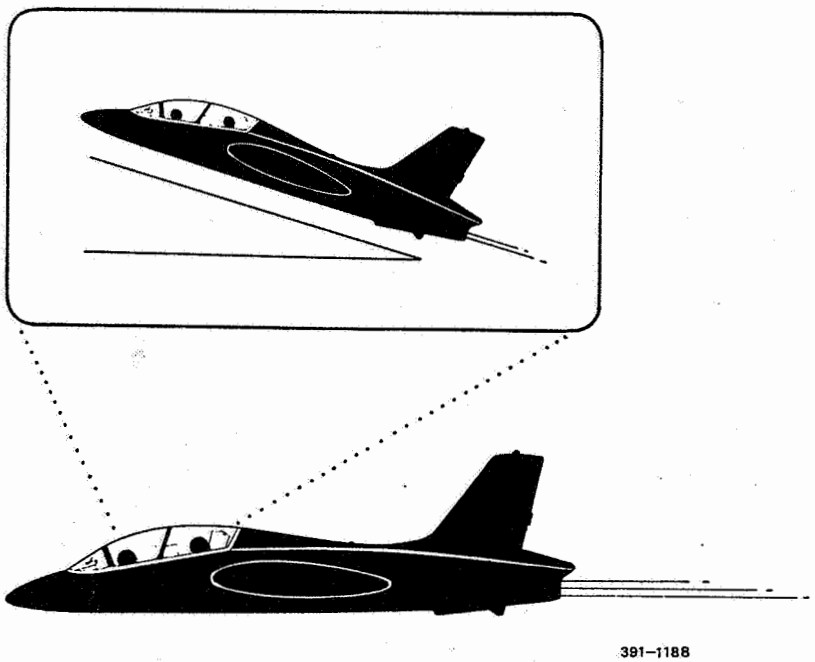


Figure 10-9. False Sensation of Upright During Acceleration

(g) Blending of earth and sky. Sometimes pilots confuse ground lights with stars. In doing so, the possibility exists of flying into the ground because the perceived horizon is below the actual one. Sometimes pilots confuse unlighted areas of the earth with an overcast night sky. They are likely to perceive certain ground features such as a seashore as the horizon and fly into the unlighted water or terrain above it.

(h) False vertical and horizontal cues. Flying over sloping cloud decks or land that slopes gradually upward into mountainous terrain often compels pilots to fly with their wings parallel to the slope rather than straight and level. A related phenomenon is the disorientation caused by the aurora borealis in which false vertical and horizontal cues generated by the aurora result in attitude confusion in the pilot.

(i) Relative motion. An adjacent automobile creeping forward at a stop light can create the illusion that your own vehicle is creeping backwards. In formation flying, such illusions are common.

(j) Visual autokinesis. A stationary light stared at for several seconds in the dark will appear to move. This phenomenon can cause considerable confusion in pilots flying formation at night.

(k) The seat-of-the pants sense. This is a misleading sense because during coordinated flight the forces resulting from centrifugal force and gravity are always toward the floor of the aircraft. Thus, pilots can never tell through their pressure sensors which direction is the true vertical.

(l) Flicker vertigo. This can be caused by the passage of light through propellers or rotor blades, and by rotating beacons flickering against an overcast sky. Light flickering at certain frequencies from 4 to 20 times per second, can produce unpleasant and dangerous reactions. These reactions may include nausea, dizziness, convulsions and unconsciousness.

(2) Conditions most conducive to spatial disorientation accidents and incidents. When a pilot is extremely busy manipulating the cockpit controls, anxious, mentally stressed or fatigued, the pilot's proficiency on instruments and formation flying is decreased. Hypoxia, various medicines (particularly amphetamines and barbiturates), G stresses, temperature stresses and emotional problems reduce the pilot's ability to resist spatial disorientation.
Pilots of jet aircraft suffer from spatial disorientation more frequently than pilots flying slower aircraft.
Pilots with less actual instrument time are more susceptible to spatial disorientation than more experienced pilots. Many spatial disorientation accidents and incidents have been reported during the penetration turn, final approach, climb out after takeoff and while performing high performance flight maneuvers.
This is when the Coriolis and somatogravic illusions are the most devastating. Other very critical times are night and weather formation flights, when the wingman loses sight of the lead in weather or when a pilot flying in VMC (visual meteorological condition) suddenly enters IMC (instrument meteorological condition). The maneuvering associated with air-to--ground ordnance deliveries, especially at night or periods of reduced visibility, is highly susceptible to disorientation accidents.
Flying in the vicinity of thunderstorms may also contribute to spatial disorientation due to turbulence, flash blindness, and equipment loss from lightning strikes. (Spatial disorientation may be accompanied by hyperventilation).

(3) Inducing spatial disorientation. A number of maneuvers can be used to induce spatial disorientation.
Each maneuver normally creates a specific reaction; however, any reaction resulting in a false sensation is effective.

The purpose of these maneuvers is to help students understand how susceptible the human system is to disorientation. The maneuvers demonstrate that interpretations of aircraft attitudes from bodily sensations are frequently unrealistic. The maneuvers also provide a better understanding of how disorientation relates to aircraft motion and head movement. They instill in the pilots greater confidence in flight instrument interpretation by the sense of sight to determine the aircraft attitude.

(4) Spatial disorientation maneuvers. The following spatial disorientation maneuvers are selected because of their relation to normal instrument or turbulent flight. These maneuvers should be simulated and practiced only under direct supervision. They should not be accomplished in a single-seat aircraft.
Other maneuvers, more violent and prolonged, may have a disorienting effect; however they are not the type of maneuver or situation likely to be inadvertently encountered.

(a) Sensation of climbing while turning. This sensation can be induced by having the pilot's eyes closed while the aircraft is in a straight and level attitude. The supervisory pilot should execute, with a relatively slow entry, a well coordinated 90° turn using approx. 1.5 positive Gs. While the aircraft is turning under the effect of positive G and the pilot's eyes still closed, the supervisory pilot should ask the pilot's impression of the aircraft attitude. The usual sensation is that of a climb.
The pilot, with eyes open, can then see that a slowly established coordinated turn produces a climb sensation from the action of centrifugal force (+G) on the equilibrium organs.

- Correlation under actual instrument conditions. If the aircraft enters a slight, coordinated turn in either direction while the pilot's eyes are diverted away from the instruments, the sensation of a nose-up attitude may occur.
Positive G is usually associated with a climb; negative G with a dive. This association is an unconscious habit developed through experience with G forces as well as a conscious feeling of climbing or diving due to the effect of gravity on the inner mechanisms of the ear.

(b) Sensation of diving during recovery from a turn. This sensation can be created by repeating the turning procedure described above, except that the pilot keeps the eyes closed until the recovery from the turn is approximately one-half completed. While the recovery is being executed and with the pilot's eyes still closed, the supervisory pilot should observe the pilot's impression of the aircraft attitude. The usual response is that the aircraft is descending. This false sensation is apparent when the pilot opens the eyes while the aircraft is still recovering from the turn.

- Correlation under actual instrument conditions. If the eyes are diverted from the instruments during a turn under instrument conditions a slow and inadvertent recovery will cause the body to perceive only the decrease in positive G force. This sensation causes the pilot to believe the aircraft has entered a descent.

(c) False sensation of tilting to right or left. This sensation may be induced from a straight and level attitude with pilot's eyes closed. The supervisory pilot should maintain wings level and use rudder to produce a slight skid to the left. The usual sensation is that of being tilted to the right. This false sensation is the effect of side-to-side accelerative forces on the organs of equilibrium.

- Correlation under actual instrument conditions: if the eyes are momentarily diverted from the instruments as a skid to one side occurs, a false sensation of tilting the body to the opposite side may occur.

(d) False sensation of reversal of motion. This false sensation can be demonstrated in any one of the three planes of motion. The pilot should close the eyes while in straight and level flight. The supervisory pilot should roll the aircraft at a constant rate of 1° to 2° per second to a 30° to 45° bank angle. The roll should be stopped abruptly and the bank attitude held. The usual reaction is the sense of rapid rotation in the opposite direction. After this false sensation is noted, the supervisory pilot should have the pilot open the eyes and observe the aircraft attitude. The false sensations produced from stopping the roll abruptly may result in a strong urge to apply reverse aileron pressure for recovery.
This sensation can also be demonstrated by abruptly ending a constant velocity yaw after 20 to 30 seconds duration.

- Correlation under actual instrument conditions. If the aircraft rolls or yaws with an abrupt stop while the eyes are diverted from the instruments, a sensation of rolling or yawing to the opposite direction may occur. Therefore, the natural response to this false sensation would result in a reentry or an increase of the originale roll or yaw. This response is a common error in rolls or spins when the visual references are poor. The sense of sight is the only sense which should be relied upon for correct recovery techniques.

(e) Sensation of diving and/or rolling beyond the vertical plane. This maneuver should be started from straight and level flight while the pilot closes the eyes. The supervisory pilot should start a normal coordinated turn to between 30 and 45° of bank. As the aircraft is turning, the pilot should lean forward and turn the head to either side, then rapidly resume the normal upright position. The supervisory pilot should time the maneuver so that the turn is stopped just as the pilot resumes the normal position. This maneuver usually produces disorientation by giving the sensation of falling in the direction of roll and downward. This sensation may result in a quick and forcible movement upward and backward in the opposite direction. The physical response associated with this type of sensation can be very dangerous if it occurs at low altitude.

- Correlation under actual instrument conditions: severe spatial disorientation may result when the aircraft enters a turn while the pilot's head is moved down and sideways and then returned to the upright position. The usual reflex and almost uncontrollable urge to move physically in the opposite direction may be transferred to the aircraft controls. If this reflex is not controlled, it could easily cause exaggerated aircraft attitudes and further disorientation.
The pilot's duties likely to create this sensation under IMC are mainly the following:

- changing radio channels/frequencies
- reaching for maps or charts, instrument procedures, etc.
- looking for obscure switches and controls.

The degree of disorientation depends upon the motion of the aircraft, the motion of the head, and the time element.

NOTE

Exercise extreme care to limit rapid head movements during IMC descents and turns. Cockpit duties should be subordinate to maintaining aircraft control. If possible delegate those duties to the other crew member.

(f) Sensations of climbing. This maneuver may be demonstrated by starting from straight and level flight at the aircraft normal final approach airspeed. While the pilot closes the eyes, the supervisory pilot should increase the airspeed and maintain straight and level flight. During the latter part of the airspeed increase, the supervisory pilot should ask the pilot, whose eyes are still closed, what is his sensation of the aircraft attitude. The usual sensation perceived without visual reference is that the aircraft is climbing.

- Correlation under actual instrument conditions: this sensation may be very strong during an instrument missed approach. The false sensation of an excessive climb is produced by the change in aircraft attitude and aircraft acceleration. The degree of disorientation and physical response depends upon the attitude change and the rate of aircraft acceleration.

(5) Maintaining spatial orientation (fig. 10-10). The pilot will become less susceptible to these false sensations as he acquires additional instrument experience.

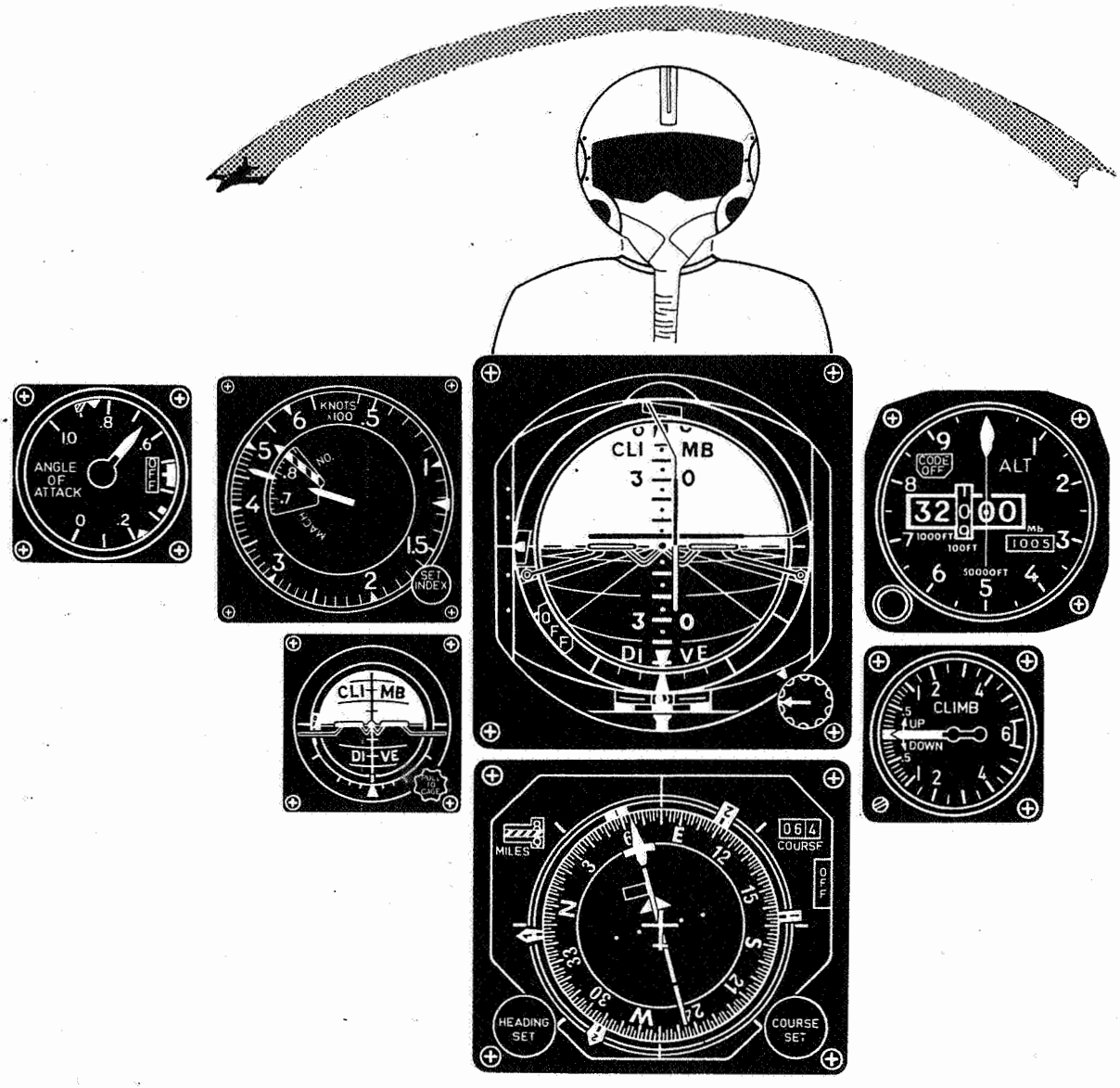


Figure 10-10. Maintain Attitude on the Instruments

The false sensations of flight are experienced by normal people. These unpleasant and adverse sensations cannot be prevented and eliminated but they can be ignored or suppressed by relying on instrument indications of aircraft attitude.
The pilot must learn to rely on the instruments and ignore the false sensations.
The practice and experience gained with instrument flying will help the pilot overcome the false sensations and maintain the orientation. The pilot will then become less susceptible to sensations perceived from the supporting sense; it must however be borne in mind that when a pilot has not been flying for long periods or is poorly trained in instrument flying, he becomes more susceptible to vertigo and disorientation.

3. ATTITUDE INSTRUMENTS

The operation of attitude instruments and any instruments used in instrument flying is detailed in "Instrument Flying and Navigation Manual" PI AD-03-39A.

a. Performance Instruments (fig. 10-11)

The indications needed to attain and maintain the required flight parameters are given by the PERFORMANCE INSTRUMENTS.

b. Control Instruments (fig. 10-12)

The instruments which display attitude and power indications are the CONTROL INSTRUMENTS, they thus permit the aircraft to be controlled basing on these indications.

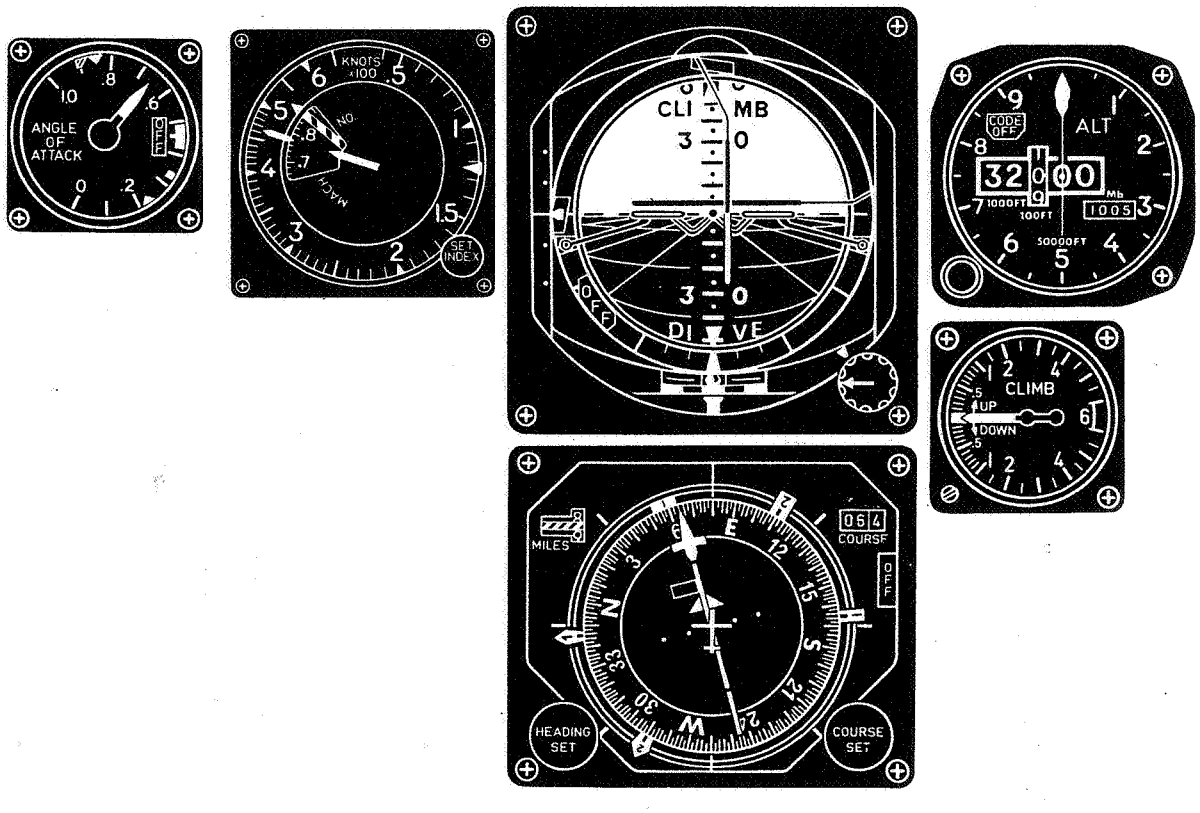


Figure 10-11. Performance Instruments

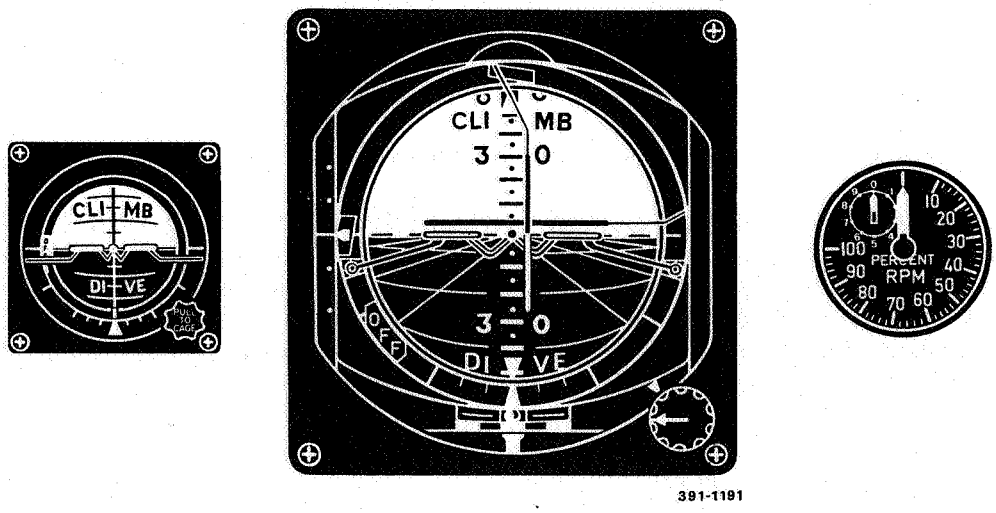


Figure 10-12. Control and Navigation Instruments

Besides the performance and control instruments there are the NAVIGATION instruments which indicate the position of the aircraft in relation to geographical points and/or radioaids, and the IDENTIFICATION equipment (IFF/SIF), which avails of special radioelectrical codes.

NOTE

The instruments indicating the operation of the aircraft/ /engine/systems etc. should also be monitored, even if at intervals, the attention of the pilot being obviously concentrated for most of the time on the CONTROL AND PERFORMANCE INSTRUMENTS.

c. Technique of Instrument Flying

(1) Maintain the indications of the maneuver instruments constant (ATTITUDE - RPM)

(2) Check the performance instruments to discover any deviation

(3) If there is a deviation, apply the correction acting on attitude (stick) and power (throttle) controls.

(4) Concurrently check the response to control input (refer to the ADI for the control stick and to the tachometer for the throttle lever).

(5) Check on the performance instruments that the flight parameters are as desired (viz. altitude, heading, airspeed, vertical velocity, and if required, the turn rate).

d. Controlling the Attitude

In order to correctly pilot the aircraft on the instruments, the pilot should first of all be able to interpret the indications of the ADI artificial horizon (fig. 10-13) (or the standby attitude indicator) in the same way as in visual flying he refers to the earth horizon.
With respect to the attitude indicators of older design, the ADI installed in the MB-339A offers a few advantages as follows:

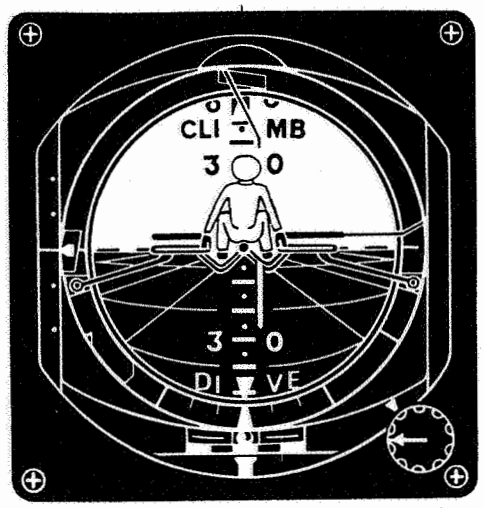


Figure 10-13. Pilot Position as to the Attitude Indicator

- It is not suceptible to precession during the accelerated maneuvers (viz. in turn and during airspeed changes)

- Its indications are precise up to a tenth of degree

- The line representing the horizon separates the black area from the light gray area of the sphere, therefore no confusion between "up" and "down" is now possible as conversely occurred sometimes when the old J8 instrument was used.

For further details, the pilot should refer to publication PI AD-03-39A.

The artificial horizon, which will henceforth more properly be called attitude indicator, permits even small changes in pitch and roll attitudes to be identified.

The interpretation of the indications is extremely instinctive; the pilot should imagine that he is flying the aircraft symbol sitting on the dot (which represents the fuselage), pointing inside the instrument and using the symbol wings as a handlebar.

As far as the yaw axis is concerned, the pilot will refer to the ball of the turn and bank indicator and bear in mind that application of opposite rudder brings the ball back to center.

(1) Longitudinal attitude control. When the altimeter reading does not change and the vertical velocity indicator is at zero (for at least three seconds), check the position of the dot in relation to the ADI sphere horizon.

Memorize this position as the "level flight attitude" or move the sphere until its horizon is aligned with the dot by operating the horizon line adjusting knob.

The attitude changes are displayed on the sphere by dots and marks, each representing 5°.

(2) Roll control. To accomplish a turn with a precise bank angle refer to the bank pointer which moves along the bank scale, whose markings represent 10°-20°-30°-60°-90°.

(3) Interpretation of the instrument indications. It is necessary to bear in mind that no instrument alone can provide indications on which the pilot can always totally rely, even if the ADI, which has no precession errors, should in all cases give realiable and clear indications (... provided it operates OK); it is thus appropriate for the pilot to

cross-check the attitudes displayed on the ADI on other instruments, and namely:

- for roll attitude on the turn and bank indicator and HSI gyrocompass.

- for pitch attitude on the altimeter, airspeed indicator and vertical velocity indicator.

e. Power Control

For a correct use of power in instrument flying, it is necessary to know a priori the RPM values required for any attitude and airspeed to be used for different maneuvers, and therefore retard or advance the throttle lever timely and adequately.

f. Performance and Performance Instruments

The performance instruments are those instruments which permit the parameters established for the different maneuvers to be monitored, evaluated and maintained.
The performance instruments are the following:

- Altimeter
- Vertical velocity indicator
- Airspeed indicator
- AOA indicator
- Gyrocompass
- Turn and bank indicator

(1) Altimeter (fig. 10-14): it provides an approximate and delayed indication of the pitch attitude through the subsequent altitude readings.
It must be borne in mind that the instrument is susceptible to many errors.
See PI AD-03-39A for a complete description and operation

(2) Mach airspeed indicator (fig. 10-15): it provides the following three indications:

- Airspeed
- Vne (never exceed airspeed)
- Mach number

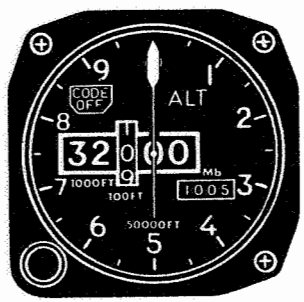


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Figure 10-14. Drum - Counter - Pointer Altimeter

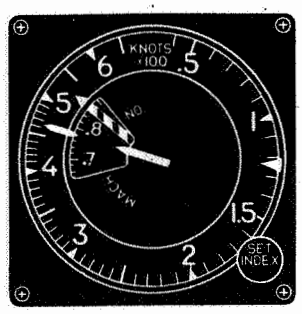


Figure 10-15. Mach - Airspeed Indicator

For further details see PI AD-03-39A

(3) Vertical velocity indicator (fig. 10-16): the vertical velocity indicator provides an indirect indication of pitch attitude.
Under transient conditions (viz. when vertical velocity is changing) it suffers from hysteresis.
The instrument interpretation is twofold as follows:

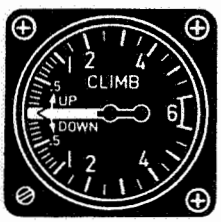
- in transient conditions it provides an indication of the trend according to which the pitch attitude changes

- in conditions of stabilized vertical velocity, it provides the correct values of the climb/descent rates.

(4) Tachometer (fig. 10-17): it accurately indicates the rotation speed of the engine shaft as a percentage of the maximum nominal revolutions (100% - 13 760 revolutions per minute).
A small dial, in the left upper corner of the instrument permits an easy reading of the value with an accuracy of up to 1% RPM.

(5) Gyrocompass (fig. 10-18): the compass card is controlled by a very stable and precise directional gyro which receives electrical signals from a sensing element, called "Flux Valve" and activated by the earth magnetic field.

1. ANEROID CAPSULE
2. HAIR TUBE
3. STATIC PRESSURE PORT



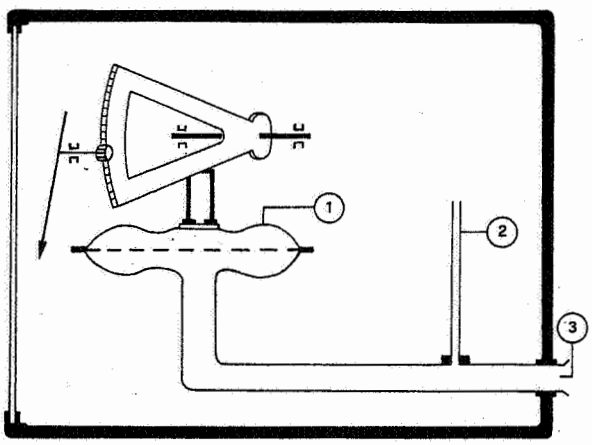


Figure 10-16. Vertical Velocity Indicator

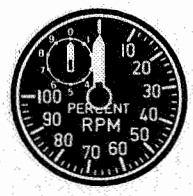


Figure 10-17. Tachometer or RPM Indicator

In the HSI, the compass card rotates to display the aircraft heading under the vertical fixed lubber line and the miniature aircraft placed at the center of the HSI, by reference to the magnetic north. The "HEADING SET" knob permits the heading marker (which consists of a white rectangle with a black reference line at center), to be set to a desired heading.
The gyrocompass is practically free from errors. In case of malfunction of the gyroplatform it can be used as a normal magnetic compass by setting the "Mode Selector" switch on the AHRS control panel to the EMERG position (See FM, Section I and "Instrument Flying and Navigation Manual").
In case of malfunction of the sensing element (flux valve), the AHRS platform can be used as a free directional gyro by setting the mode selector to DG and by aligning, by the AHRS "SET HDG" knob, the compass card with the magnetic heading displayed on the stand-by compass (in straight and level flight).

(6) Stand-by compass (fig. 10-19). The magnetic compass is susceptible to considerable errors if read in the following conditions:

- Changing airspeed
- Changing heading

These errors are as a function of the true airspeed and angular velocity, latitude and vertical component of the earth magnetic field. If the stand-by compass is to be used because of failure of the gyrocompass, it is essential that the required leads and delays be considered when rolling out of a turn. For turns accomplished with the standard bank angle of 30°, at a NORTH latitude between 40° and 45°, and constant airspeed, these values are as follows:

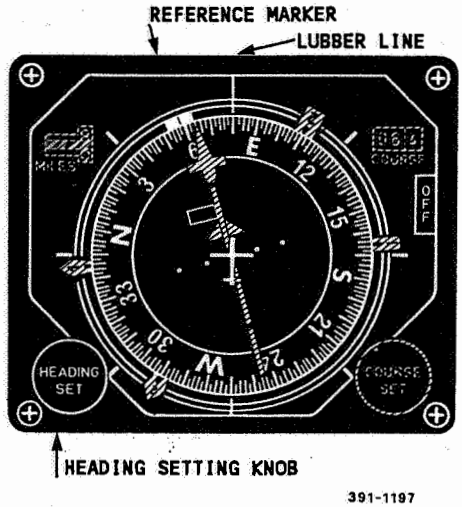


Figure 10-18. Gyrocompass or HSI

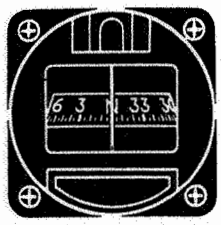


Figure 10-19. Standby Magnetic Compass

TURNING towards NORTH rollout with a lead of approx. 33°
TURNING towards SOUTH delay rollout by approx. 22°
TURNING towards EAST / TURNING towards WEST } rollout with a lead of 6° when coming from SOUTHERLY sectors.
TURNING towards EAST / TURNING towards WEST } rollout with a lead of 12° when coming from NORTHERLY sectors.

When airspeed is increasing: apply above corrections plus a further slight correction towards the SOUTH.
When speed is decreasing: apply above corrections plus a further slight correction towards the NORTH.
Refer to the FM and "Instrument Flying and Navigation Manual".

(7) Turn and bank indicator. In the MB-339A aircraft the turn and bank indicator is included in the lower part of the ADI instrument.
A displacement of the turn needle with respect to the central mark so that the needle edge and the mark edge are aligned, corresponds to a rate of turn of 1,5° per second (360° turn in 4 minutes/90° per minute). A displacement of the turn needle so that it overlaps a lateral mark corresponds to a rate of turn of 3° per second (360° turn in 2 minutes/90° in 30 seconds). Beyond 3 degrees/second, the indications are not proportional to the rate of turn but are consistent with the correct turning direction, and this also when the aircraft is inverted, viz. to the pilot's left side/to the pilot's right side.
A gyro separated from and independent of the gyroplatform has been installed to provide indications also in inverted attitudes.
Non-skidding flight and coordinated turns are performed maintaining the ball centered.

Remember that, as said before, opposite rudder brings the ball back to center, while the same action displaces the turn needle in the other direction.

(8) AOA indicator. AOA means angle of attack α. The AOA system is detailed in the "Instrument Flying and Navigation Manual" and the FM. The AOA indicator indicates the wing chord angle α in relative units from zero to one, where zero is the null lift attitude and one is the full stall attitude.
When flying on the AOA indicator, stall, stall warning, optimum glidepath, maximum range, maximum endurance will always be flown with the same AOA value, irrespective of the aircraft mass and altitude.
Bear in mind the following:

- The stall always occurs when the AOA is beyond 0.86, with flaps down, at T.O. or up.

- The optimum approach AOA with flaps down is 0.45, while with flaps up or in the T/O position this AOA is 0.60.

- The AOA's for maximum endurance (0.33), maximum range (0.23) are only applicable to the aircraft with the landing gear and flaps up.

The AOA system is very important for flying high performance aircraft, it is essential in the combat aircraft and is of great help in trainers, for the following reasons:

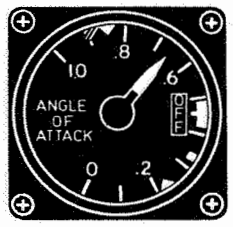
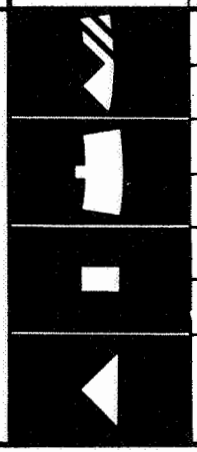
- The pilot familiarizes with the piloting techniques that are used in combat aircraft.

- It is an extremely useful auxiliary instrument which becomes of primary importance in case of airspeed indicator malfunction.
The markings on the instrument dial are shown in figure 10-20.

NOTE

The AOA, 3 o'clock position viz. 0.45 indication, refers to the downwind leg of the landing pattern, aircraft with flaps UP and then at T/O, and to final approach, aircraft with flaps DOWN.

The above AOA values must be recorded or noted so that they can be used for flight, approach and landing in case of Mach-airspeed indicator failure.

AOA INDICATOR	MARKING	INDICATION	CONDITION
		.90	LOW ALTITUDE STALL IN ANY CONFIGURATION
		.85	STALL WARNING WITH FLAPS AND LANDING GEAR DOWN
		.45	TRAFFIC PATTERN: DOWNWIND AND BASE WITH FLAPS UP OR T/O
		.45	APPROACH WITH FLAPS AND LANDING GEAR DOWN
		.33	AOA FOR LANDING GEAR LOWERING
		.33	MAX ENDURANCE
		.23	MAX RANGE

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NOT MARKED REFERENCES ON AOA INDICATOR	
150 KIAS GLIDE SLOPE IN CASE OF ENGINE FLAMEOUT	.42
106 KIAS PRE-STALL WARNING IN CLEAN CONFIGURATION, FLAPS UP	.82
125 KIAS FLAP UP OR T/O FINAL APPROACH	.60
200 KIAS TRAFFIC CIRCUIT, LOW SPEED	.27
250 KIAS CRUISE AND TRAFFIC PATTERN (AVERAGE)	.24
MAXIMUM PERFORMANCE TURNS (HIGH G LOW ALTITUDE)	.60

Figure 10-20. AOA Indicator Markings

4. ATTITUDE CONTROL TECHNIQUE

To control the aircraft attitude and obtain the desired performance, the following procedure is to be considered:

- Establish an attitude and/or power setting on the control instrument, which would result in the desired performance.

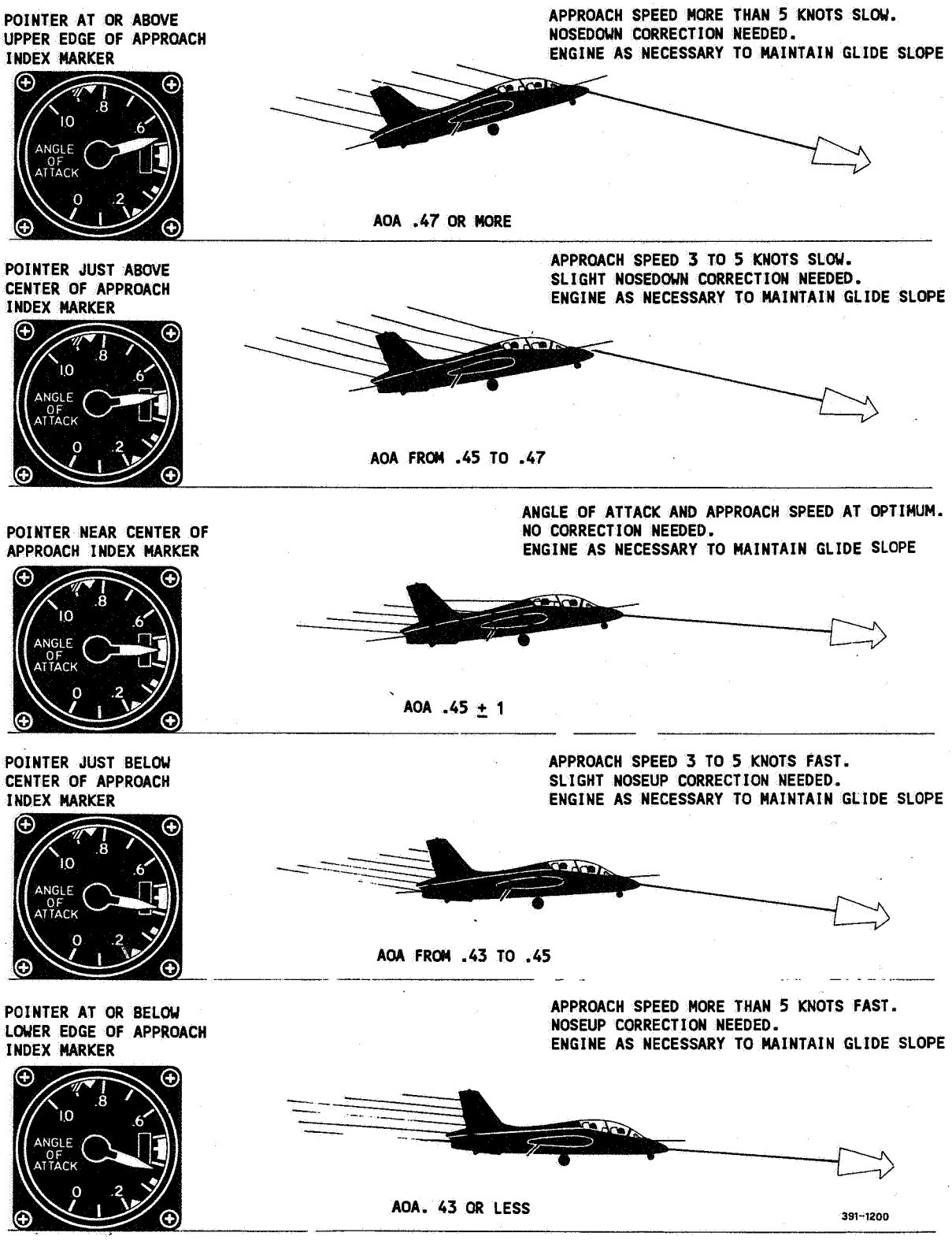

POINTER AT OR ABOVE UPPER EDGE OF APPROACH INDEX MARKER
APPROACH SPEED MORE THAN 5 KNOTS SLOW.
NOSEDOWN CORRECTION NEEDED.
ENGINE AS NECESSARY TO MAINTAIN GLIDE SLOPE
ANGLE OF ATTACK
AOA .47 OR MORE
POINTER JUST ABOVE CENTER OF APPROACH INDEX MARKER
APPROACH SPEED 3 TO 5 KNOTS SLOW.
SLIGHT NOSEDOWN CORRECTION NEEDED.
ENGINE AS NECESSARY TO MAINTAIN GLIDE SLOPE
AOA FROM .45 TO .47
POINTER NEAR CENTER OF APPROACH INDEX MARKER
ANGLE OF ATTACK AND APPROACH SPEED AT OPTIMUM.
NO CORRECTION NEEDED.
ENGINE AS NECESSARY TO MAINTAIN GLIDE SLOPE
AOA .45 ± 1
POINTER JUST BELOW CENTER OF APPROACH INDEX MARKER
APPROACH SPEED 3 TO 5 KNOTS FAST.
SLIGHT NOSEUP CORRECTION NEEDED.
ENGINE AS NECESSARY TO MAINTAIN GLIDE SLOPE
AOA FROM .43 TO .45
POINTER AT OR BELOW LOWER EDGE OF APPROACH INDEX MARKER
APPROACH SPEED MORE THAN 5 KNOTS FAST.
NOSEUP CORRECTION NEEDED.
ENGINE AS NECESSARY TO MAINTAIN GLIDE SLOPE
AOA. 43 OR LESS
391-1200

Figure 10-21. Use of AOA Indicator on Approach

- Cross-check the performance instruments to determine if the established attitude and/or power setting result in the desired performance.

- If necessary correct the attitude and/or power by monitoring the control instruments.

- Trim until the effort on the controls becomes nil

a. Attitude Control on the Control Instruments

(1) Pitch attitude. The changes in pitch attitude are monitored by referring to the ADI miniature aircraft which is integral with the instrument rim. These changes are expressed in degrees and can be evaluated by observing the miniature aircraft position in relation to the reference lines and dots on the sphere.

(2) Roll attitude. The changes in lateral attitude on the turn and bank indicator are monitored by observing that the bank pointer moves to the established value on the bank scale located on the instrument rim. This bank scale carries graduations at 10, 20, 30, 60 and 90° both on the left and right side.

(3) Power control. In instrument flying as well as in visual flying, a proper control of power permits the desired parameters to be established or maintained during the different flight phases.
To facilitate the accomplishment of the maneuvers, an "a priori" knowledge of the prescribed or at least the envisaged RPM is required.

b. Cross-Check (fig. 10-22)

The cross-check concept was introduced above, when the control and performance instruments were described. The cross-check consists in a balanced sharing of attention amongst the instruments in order to read and interpret them correctly. Attention must be divided between the control and performance instruments in a sequence that insures comprehensive coverage of the flight instruments.
The ADI being the instrument which provides the promptest indications, it should be checked most often, while the other instruments should be inserted in the cross-check time by time.
The above means that all instruments should be read alternatively so that the pilot can devote his attention in proportion to the importance that an instrument has in any specific flight phase.
This cross-check technique can be compared for the arrangement of the instruments in the MB-339A to a wagon wheel. The hub represents the ADI and the spokes the performance instruments.

NOTE

It is an error to devote so much attention to the instrument whose indication is most important; this will result in omission of reference to other instruments with a negative impact on the attitude visualization.

In conclusion of the above, it is worth remembering that the cross-check permits the aircraft incorrect tendencies to be immediately identified and reversed when the error occurs and the corrective action to be timely taken. This avoids the "chasing" of the instruments and overcontrolling.

c. Use of the Trim

(1) Proper use of the trims is essential for coordinated and precise

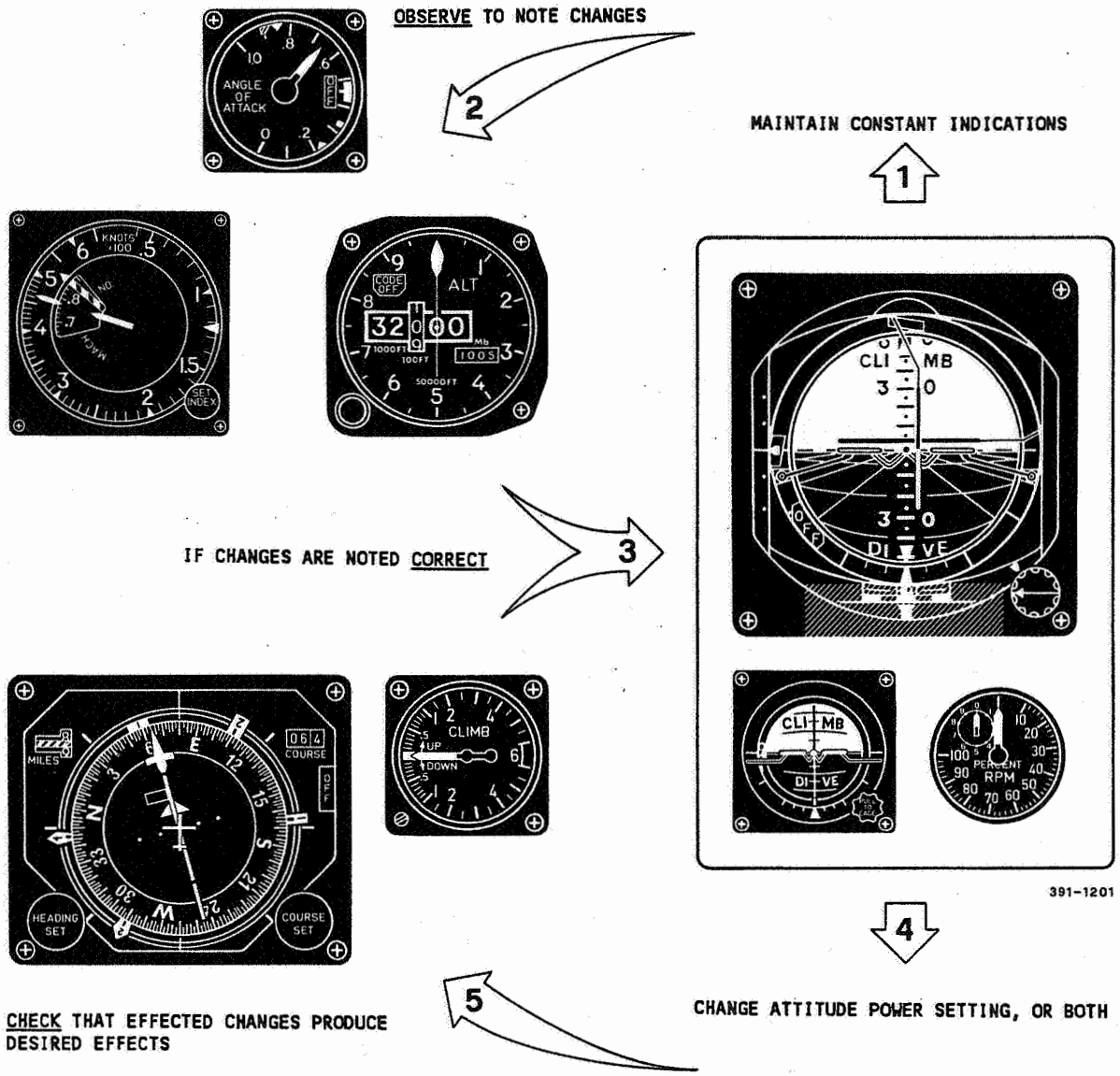


Figure 10-22. Check of Attitude

aircraft piloting during all the phases of flight.
Besides when the aircraft is trimmed, more attention can be devoted to the instruments and cockpit duties.

(2) An aircraft is trimmed by applying control pressure to establish a desired attitude on the ADI, then adjusting the trim so that control stick pressure becomes nil. It will then be necessary to check on ADI that the desired attitude is maintained, while no control stick pressure should be applied. If the ADI displays a change of attitude, repeat the procedure. For coordinated flight, check that the ball of the turn and bank indicator is centered. This is done by using rudder trim in the direction in which the ball is displaced from center.

(3) Changes of attitude, power or configuration will require a trim adjustment. From the above the following ensues:

- Do not use the trim to establish a change in aircraft attitude

- Do not use trims during the attitude changes (but when changes are completed).

5. CORRECTION TECHNIQUE

A proper correction technique is essential for a precise conduct of instrument flight.
When any indication other than that desired is observed on the performance instrument, a change of aircraft attitude and/or power is required to restore the correct parameters.

Proceed as follows:

- Stop the observed error
- Apply the appropriate corrective action
- Discontinue this action when the correct parameters are obtained.

a. Stop the Observed Error

This action must be immediate, it is accomplished by restoring on the ADI the same aircraft attitude as observed immediately before the error occurrence.

b. Application of Corrective Action

This is the most demanding phase since it requires a proper change of aircraft attitudes as a function of the discovered error. I.e. to correct a 500 ft altitude error, a change in pitch attitude corresponding to a vertical speed of 500 to 700 ft/min (equal or slightly higher than the discovered error) will be established on the ADI, changing power setting, if required, to maintain the airspeed constant.
It is therefore remembered that before establishing a corrective action, it is indispensable to know what to change (attitude and/or power) and how much to change it.
By the above technique, the corrective action will be accomplished gradually to make a normal cross-check possible.
For a heading error, apply corrective action by having the ADI horizon line inclined by a quantity equal to the noted error; a 10° heading error can be corrected by banking the wings 10°. For errors in excess of 30° of heading, the wings will always be banked 30° max.

c. Discontinue the Corrective Action

During the application of the corrective action increase the cross-check frequency in order to be ready to restore the desired attitudes and parameters with the applicable lead.

NOTE

In any case the reason which caused the error should always be investigated and removed.

d. Use of Auxiliary Controls

For the use of speedbrake and flaps the same considerations as for the visual flying are applicable.
All attitude changes caused by the actuation of speedbrake and flaps must be referred to the ADI.
If such changes are to be opposed, the pilot must actuate the control stick and then trim the aircraft longitudinally.

PART THREE - CHAPTER X

SECTION B - BASIC INSTRUMENT FLYING

1. GROUND MANEUVERS

The ground checks prescribed for instrument flying are the same as for visual flying; in particular, the student pilot is required to perform the following tasks:

- exterior checks
- interior checks (in particular in the rear cockpit, which is the pilot's seat assigned to him);
- participation in the pre-start and start checks;
- tuning and test of the radio aids
- check of navigation instruments in the rear cockpit (QNH, altimeter error, time check);
- taxi checks, before line up checks and runway checks

All other checks are a task of the instructor (engine start, radio calls, taxi and alignment maneuvers).

2. GENERAL INFORMATION ON INSTRUMENT FLYING

During instrument flying the aircraft is flown as in visual flight, except for the outside references that are replaced by the instrument (ADI for attitude and HSI for heading)
The piloting procedures that are briefly described hereafter must be adopted only after reading Section II and Section VII of the FM and the "Instrument Flying and Navigation Manual".

3. INSTRUMENT TAKE-OFF

a. Before Take-off

The instrument take-off flown with the blind flying hood in place, has didactical purposes only.
In actual conditions, the pilot will have to perform the take-off with a visibility compatible with his instrument rating.
Once clearance to enter the runway for instrument take-off is obtained from the tower, enter the runway and line up with the runway centerline.
In dual flights, this maneuver is carried out by the instructor.

(1) Once lined up on the runway (in dual flights only after instructor's consent), carry out the checks as prescribed for VFR flights.

(2) Check again that the altimeter is set on the QNH: it must indicate the known runway end elevation ± 75 ft max.

NOTE

This check is carried out before leaving the parking area too.

(3) With the HEADING SET knob, set a heading equal to the heading taken when perfectly lined up on the runway

(4) If take-off is made with the aid of the flight director press the HDG key on the FLT DIR panel and check that it illuminates. The amber vertical bar on the ADI must be centered. If it is even slightly off center, act on the HEADING SET knob and align it.

NOTE

The FLT DIR take-off procedure is flown for demonstration purposes only, and is not normally used during training.

b. Instrument Take-off

(1) Set engine at 100% RPM - Check RPM, JPT, flowmeter.

(2) Release brakes

(3) Maintain direction with differential application of brakes up to 50 KIAS. Use runway markings and lights if in IMC. If the blind flying hood is in place, concentrate on the HSI (or the ADI vertical bar).

(4) At 90 KIAS, apply a slight back pressure on the control stick until a 8° nose-up attitude is attained on the ADI; this is shown by the center dot of the miniature aircraft touching the top of the 5° dot.

(5) When a speed of 100 KIAS is obtained in a 8° nose-up attitude, lift-off will occur.
Maintain longitudinal and lateral attitude using the ADI as the main reference.

(6) When the vertical speed indicator indicates a climb and the altimeter reads with an altitude gain, retract the landing gear.

(7) Beyond 120 KIAS, retract the flaps and trim the aircraft.

(8) Maintain an 8° nose-up attitude until a rate of climb of 1500 ft/min is obtained, then, if required, slightly reduce the attitude to stabilize the rate of climb at 1500 ft/min, allowing the aircraft to accelerate.
During acceleration, turns with a maximum bank angle of 30° can be flown, provided airspeed is above 150 KIAS and altitude above 500 ft AGL.
Generally, the acceleration point is in the same direction as take-off, at 1500 ft AGL, that is at the same altitude as the traffic pattern, and is attained at an airspeed of 250 KIAS (clean configuration) or 225 KIAS (ferry configuration).

(9) To maintain roll attitude, it is possible to refer to the FLIGHT DIRECTOR vertical steering bar (in HDG mode); this also permits heading to be maintained; otherwise reference can be made to the ADI sphere and HSI.

(10) During the acceleration phase and after flap retraction, carry out the after take-off checks.

c. Considerations on Instrument Take-off

(1) Prior to asking take-off clearance, make sure that the steering is disengaged.

(2) When commencing the ground run simultaneously release the brakes, and avoid slow and large actions on the rudder pedals in order not to impair directional control.

(3) Do not use the brakes when the prescribed speed is exceeded.

(4) During the take-off run, restrict cross check to the HSI (heading mark on lubber line) timely correcting the directional error with small rudder application.

(5) More closely monitor the airspeed indicator as rotation speed is approached.

(6) On rotation, which must be smooth, cross-check will essentially regard the ADI (8°) and the HSI; subsequently the vertical speed indicator and the altimeter will be included in the cross check to make sure that liff-off has occurred.

(7) At lift-off avoid taking too steep or too flat attitudes and having wings not level.

(8) Do not accomplish the cabin checks before obtaining clearance from the instructor and at any rate do not take the eyes away from the instruments to look for the landing gear and flap levers.

(9) It is important to remark that as speed increases the flight controls become more and more effective. From lift-off to the acceleration point, it is necessary to progressively reduce the pressure on the control stick and adjust the trims.

(10) Timely apply the correction technique as soon as any undesired change is noted, bearing in mind that pitch errors, and in particular nose-down errors, affect the safety of flight more than heading errors.

4. INSTRUMENT CLIMB

- Acceleration and instrument climb are flown with the same parameters as in visual flying.
See chapter V, paragraphs 2 and 3.

- A bank angle of 30° must not be exceeded during instrument climbing turns.

- During climb, the use of the flight director to maintain different headings or to intercept an outbound course, permits the bank angle to be adjusted when turning by referring to the ADI vertical bar, with no need to exceed a bank angle of 30° (for the use of the flight director, refer to the "Instrument Flying and Navigation Manual").

NOTE

In this phase, it is essential to trim the aircraft longitudinally every few seconds.

- Standard didactical instrument climb is performed as follows:

- At the acceleration point, when a IAS of 250 kt is attained (aircraft clean), or 225 kt (aircraft in ferry configuration), reduce rpm to 98% and slightly pitch the aircraft up on the ADI until an attitude of approx. 10° is attained.

- When crossing the transition altitude, enter 1013,2 mb in the altimeter.

- Maintain the envisaged speed until Mach 0.55 is attained (aircraft clean), or Mach 0.50 (aircraft in ferry configuration), then maintain this speed constant until the level-off altitude is reached.

- Carry out the periodic checks every 10 000 ft, according to the prescriptions contained in the "Pilot's Check List".

a. Considerations on Instrument climb

(1) At the acceleration point, when reducing power, do not look only at the rpm indicator, but rather concentrate attention on the ADI to set the correct attitude change.

(2) When flying turns, roll-in and roll-out must be smooth and a bank angle of 30° should not be exceeded.

(3) Carry out the periodic checks reading 2 or 3 instruments each time. If errors are found in this phase, timely take action by stopping the error first, then by accomplishing the correction, and finally complete the checks.

(4) Whenever an attitude correction is to be made, be it in pitch or roll, start the correction by referrring to the ADI, and in a second time only, resume instrument cross-check on the performance instruments.

(5) Suitably trim the aircraft taking care to use the rudder trim to keep the ball at center.

5. INSTRUMENT LEVEL-OFF AND INSTRUMENT STRAIGHT AND LEVEL FLIGHT

There apply the procedures and recommendations applicable to visual flight and described in chapter V, paragraph 4.

a. Level-off After Climb (fig. 10-23)

(1) Performance

- Start level-off with a lead of 10% on rate of climb

- Fly the maneuver smoothly until the miniature aircraft is on the horizon line

- Reduce power with a lead of some knots so that the prescribed IAS is attained and maintained (220 KIAS at FL 200 and 208 KIAS at FL 250); it corresponds to Mach 0.50

- Check the performance instruments (vertical speed indicator, airspeed indicator and altimeter) and remove any obnoxious tendency with suitable attitude changes by referring to the ADI and acting on power setting.

- Trim the aircraft for the new configuration.

- Carry out the checks as indicated in the "Pilot's Check List".

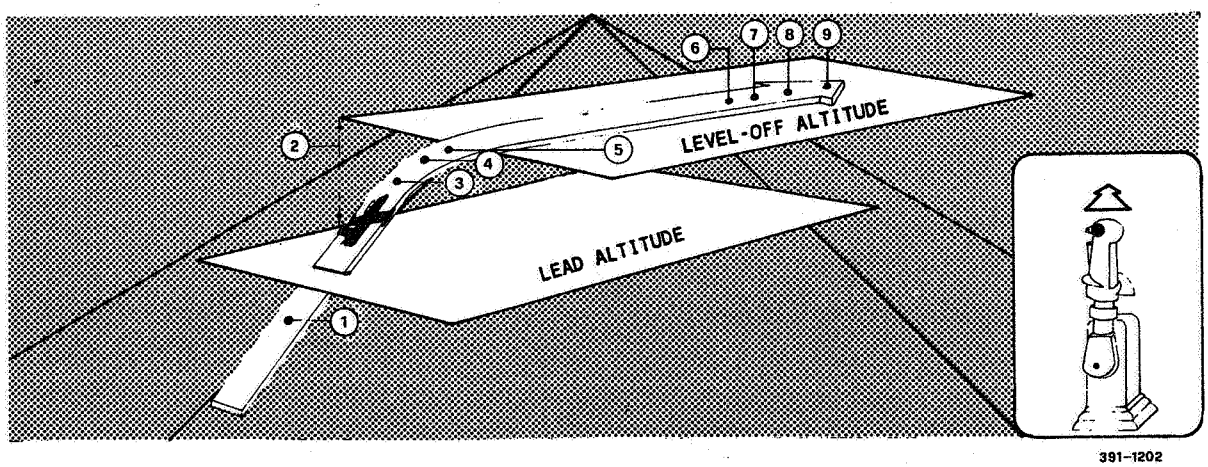
- Maintain direction by referring to the ADI (control instrument) and check heading on the gyrocompass of the HSI (performance instrument).

(2) Considerations on level-off. To reduce power as a function of the difference between climb IAS and cruise IAS, refer to the information given for the same maneuvers in visual flying.

- When about to attain the envisaged altitude, pay greater attention to the altimeter in order to avoid forgetting to level-off, or delaying it.

- Fly the maneuver smoothly to limit the extent of errors.

- Shortly before commencing the procedure, check speed for a correct power setting:
or, if climb IAS = level-off IAS: reduce RPM when lowering the nose;



1. CHECK PITCH ATTITUDE ON ADI AND VERTICAL SPEED ON THE VERTICAL VELOCITY INDICATOR (EX.: 10° AND 2000 FT/MIN)
2. LEVEL-OFF LEAD IS 10% OF VERTICAL SPEED ON VERTICAL VELOCITY INDICATOR (EX.: 200 FT)

3,4,5. WITH SMOOTH AND PROGRESSIVE FORWARD DEFLECTION OF THE CONTROL STICK (WHILE CHECKING ROLL ATTITUDE ON THE ADI), DIVIDE BY "3", THEN BY "4", THEN BY "5" PITCH ATTITUDE AND, CONSEQUENTLY, THE RATE OF CLIMB (i.e. BY "3" IT WILL BE 5° AND 1000 FT/MIN, BY "4" IT WILL BE 2.5° AND 500 FT/MIN, BY "5" IT WILL BE 1.2° AND 250 FT/MIN)

6. ADI LEVEL BOTH IN PITCH AND ROLL
7. VERTICAL VELOCITY INDICATOR READING 0, ALTIMETER READING THE DESIRED ALTITUDE
8. DESIRED HEADING (ROLL CHECK)
9. CHECK IAS, RPM AND TRIM

Figure 10-23. Instrument Level-off After Climb

or, if climb IAS is different from level-off IAS, retard the throttle earlier or later as a function of the required speed.

- Trim the aircraft when stabilized attitude and parameters are attained, and carry out the prescribed checks.

b. Staight and Level Flight

For straight and level instrument flight, the instructions given for visual flying in Chapter V, paragraphs 1 and 2 apply.

- The flight is flown at constant ALTITUDE, SPEED and HEADING. To maintain the altitude, speed and heading parameters, refer to the ADI as the control instrument.

- As in visual flying, a HOLDING technique and a CORRECTION technique are required (fig. 10-24).

(1) The holding technique envisages an attentive cross-check of the performance instruments

(2) The correction technique permits action to be taken on the controls when any error is noted on the ADI, so that:

- The noted error can be stopped if it is increasing

- An error of small and controlled extent in the opposite direction can be generated

- The opposite error can be stopped when the initial flight parameters are restored

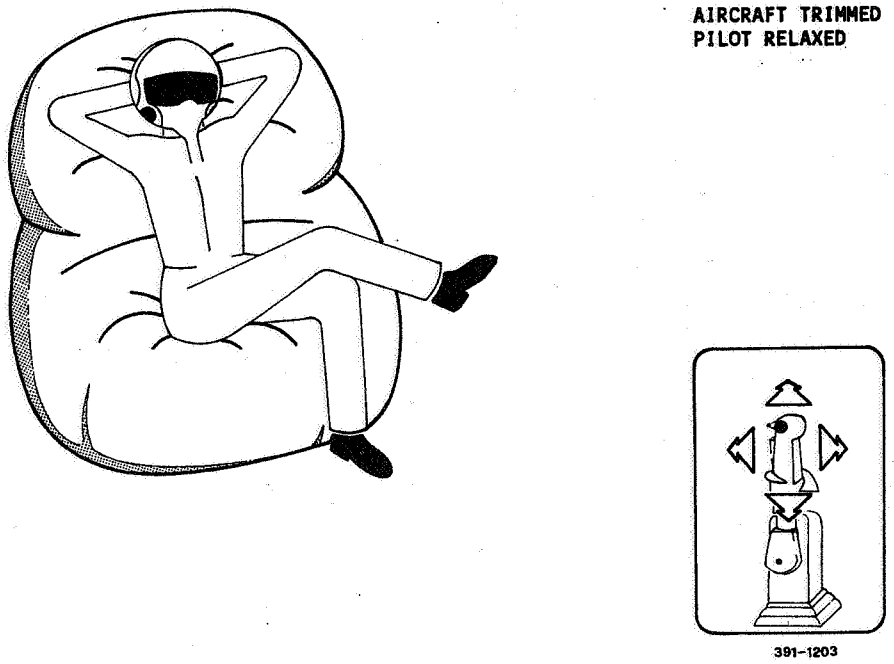


Figure 10-24. Use of the Trim in Instrument Flying

c. Performance of Training Straight and Level Instrument Flying

(1) Maintain the envisaged parameters of:

- IMN 0.5 (IMN = Indicated Mach Number)
- Heading
- Cleared flight level

(2) Carry out a thorough cross-check to maintain the parameters. The technique will be easier if trims are correctly used.

(3) Carry out the corrections as in previous step b. In the correction technique, act as imposed by the deviation magnitude and the speed with which this deviation from the envisaged parameters occurs, but never make sharp maneuvers.

(4) Carry out the periodic checks.

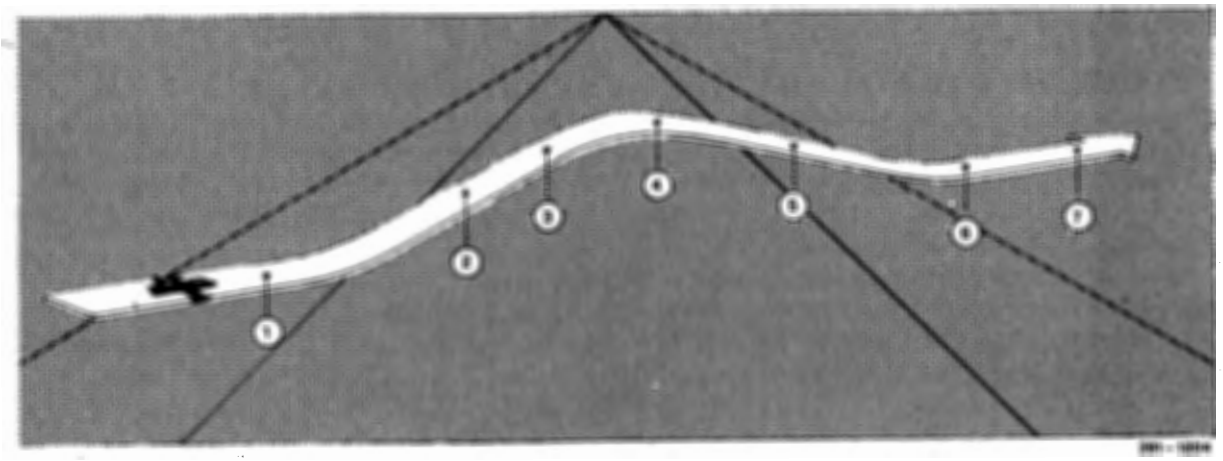
d. Considerations

(1) Avoid concentrating too much attention on holding altitude in order not to neglect heading and/or speed.

(2) Do not chase the vertical speed indicator to maintain altitude or during attitude changes, as this would result in overcontrolling in pitch.

(3) The instrument cross-check must be continuous and constant and, in case of error, it is necessary to implement the right correction technique.

(4) Remember to accurately trim the aircraft and to carry out the required checks.



1. STRAIGHT AND LEVEL FLIGHT AT CONSTANT IAS (ADI, HSI, AIRSPEED INDICATOR, ALTIMETER, AND VERTICAL VELOCITY INDICATOR OK)
2. PERCEPTION OF ERROR (VERTICAL VELOCITY INDICATOR INDICATES CLIMB, ALTIMETER READING CHANGES)
3. STOP THE ALTIMETER READING BY REFERRING TO THE ADI (ATTITUDE)
4. BY REFERRING TO THE ADI, GENTLY MOVE THE NOSE DOWN, CHECK THAT ALTIMETER READING IS DECREASING (VERTICAL VELOCITY INDICATOR READING LESS THAN -500 FT/MIN). MAINTAIN ROLL CONTROL BY REFERRING TO THE ADI
5. STOP THE ADI READING, FOLLOW ALTIMETER INDICATION. IF THE VERTICAL VELOCITY INDICATOR READS -500 FT/MIN, LEVEL-OFF WITH A LEAD OF 50 FT ON THE DESIRED ALTITUDE, USING THE ADI AS A REFERENCE.
6. TRIM, IF REQUIRED ADJUST ATTITUDE AND IAS
7. RESUME CROSS-CHECK

Figure 10-25. Maintaing Level Flight on the Instruments

e. Use of the Flight Director During Straight and Level, with no Radio Aids

This system allows both the flight level and the assigned heading to be maintained by referring to the ADI steering bars (vertical and horizontal bar).
Proceed as follows:

- Make sure that the "NAV" push-button light on the "CONTROL SHIFT" panel is on

- By rotating the "HEADING SET" knob, place the heading pointer on the desired value

- Press the "HDG" push-button on the "FLIGHT DIRECTOR" panel: the vertical steering bar will come in view. It must be kept at the center of the ADI.

- At the correct altitude, press the "ALT HOLD" push-button on the "FLIGHT DIRECTOR" panel. The horizontal steering bar will come in view; it must be kept over the miniature aircraft

NOTE

It is not necessary, but it should be preferable to have the altimeter reading unchanged, viz. the vertical speed indicator reading zero.

- This type of data presentation makes the cross-check remarkably easier, and the performance instruments will therefore be looked at only to ensure that the parameters are maintained.

- Possible corrective actions will be 'istinctive' (following the bars).

In the example shown in the figure 10-26, the pilot must pitch up slightly and move the stick a little to the right.
The use of the flight director in all phases of instrument flying is described in the "Instrument Flying and Navigation Manual" PI AD-03-39A. For information and simply to refresh the memory, the purpose of the ADI steering bars is summarized hereafter.
The bars are slaved to the flight director only, which interprets and derives (from derivative, the mathematical function) the signals of the instruments and converts them into orders for the pilot, which are always and only of the following kind:

- Horizontal steering bar: apply back pressure, stick at neutral, stick forward.

- Vertical steering bar: stick to the left, stick at center, stick to the right.

With the above actions the pilot must superimpose the center dot of the ADI miniature aircraft on the steering bars; this will be obtained with large or small movements of the stick depending on the steering bar displacement from center.
Therefore for instance, a heading error to the right, that is an actual heading greater than the desired heading, but having a trend to decrease (error extent getting smaller), can cause the vertical steering bar to order the pilot to move the stick to the the right since if the lateral attitude is not changed, the aircraft (which is out of course on the right but is turning to the left), would overshoot the desired heading and take a heading to the left of the heading selected on the HSI.

The figure 10-27 shows the trajectory flown by an aircraft in the above conditions.

NOTE

The FDS is programmed to fly all turns with a bank angle of 30° and to start roll-out with a lead of 13° on the desired heading, i.e. the heading selected by use of the "HEADING SET" knob.

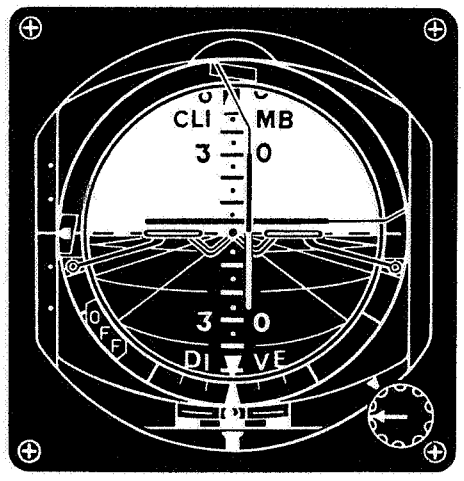


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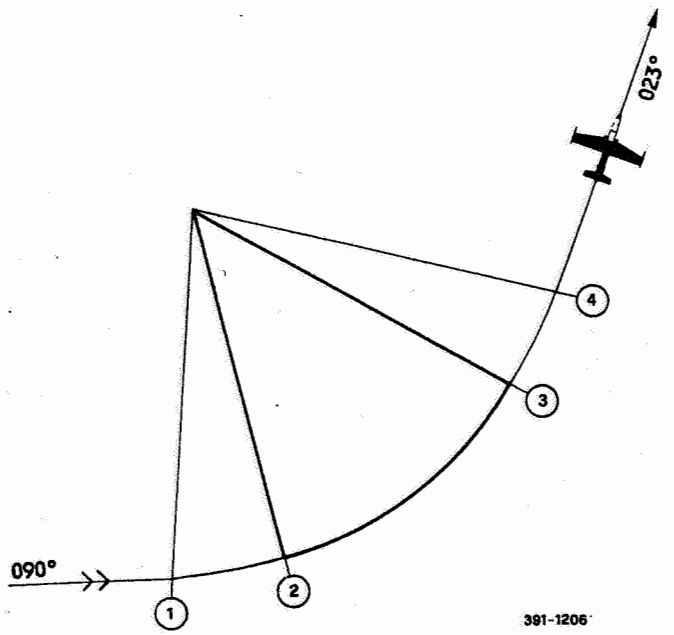
Figure 10-26. ADI Steering Bars



1. DESIRED HEADING 023°
   INITIAL HEADING 090°
   STEERING BAR TO THE LEFT, THE PILOT ROLLS TO THE LEFT
2. WHEN THE AIRCRAFT IS ABOUT TO REACH 30° OF BANK TO THE LEFT, THE BAR MOVES TOWARD THE CENTER.
   WHEN 30° OF BANK ARE ATTAINED, THE BAR IS CENTERED IN ORDER TO MAINTAIN THE BANK ANGLE UNCHANGED
3. WHEN A HEADING OF 036° IS REACHED (13° OF LEAD), THE STEERING BAR MOVES TO THE RIGHT THUS INDICATING THAT THE BANK ANGLE IS TO BE REDUCED AND A SMOOTH ROLL-OUT COMMENCED, WHICH CAUSES THE AIRCRAFT TO TAKE THE DESIRED HEADING OF 023°
4. HEADING IS 023°, WINGS LEVEL, STEERING BAR CENTERED

Figure 10-27. Operation of the Steering Bar

It is also recommended to carefully read the paragraph covering the FDS (Flight Director System) in Section I of the FM.

6. INSTRUMENT TURNS (fig. 10-28)

Instrument turns are divided into:

- TURN FLOWN ON THE GYROCOMPASS
- TIMED TURNS

a. Turns Flown on the Gyrocompass in Straight and Level Flight

The same classification used for turns flown in VFR applies to turns flown on the gyrocompass.

- The turns on the gyrocompass that are usually accomplished during instrument flying are either shallow turns or medium turns.

The pilot will however also practice steep and very steep turns to get used to implement more exacting techniques and to control extreme attitudes.

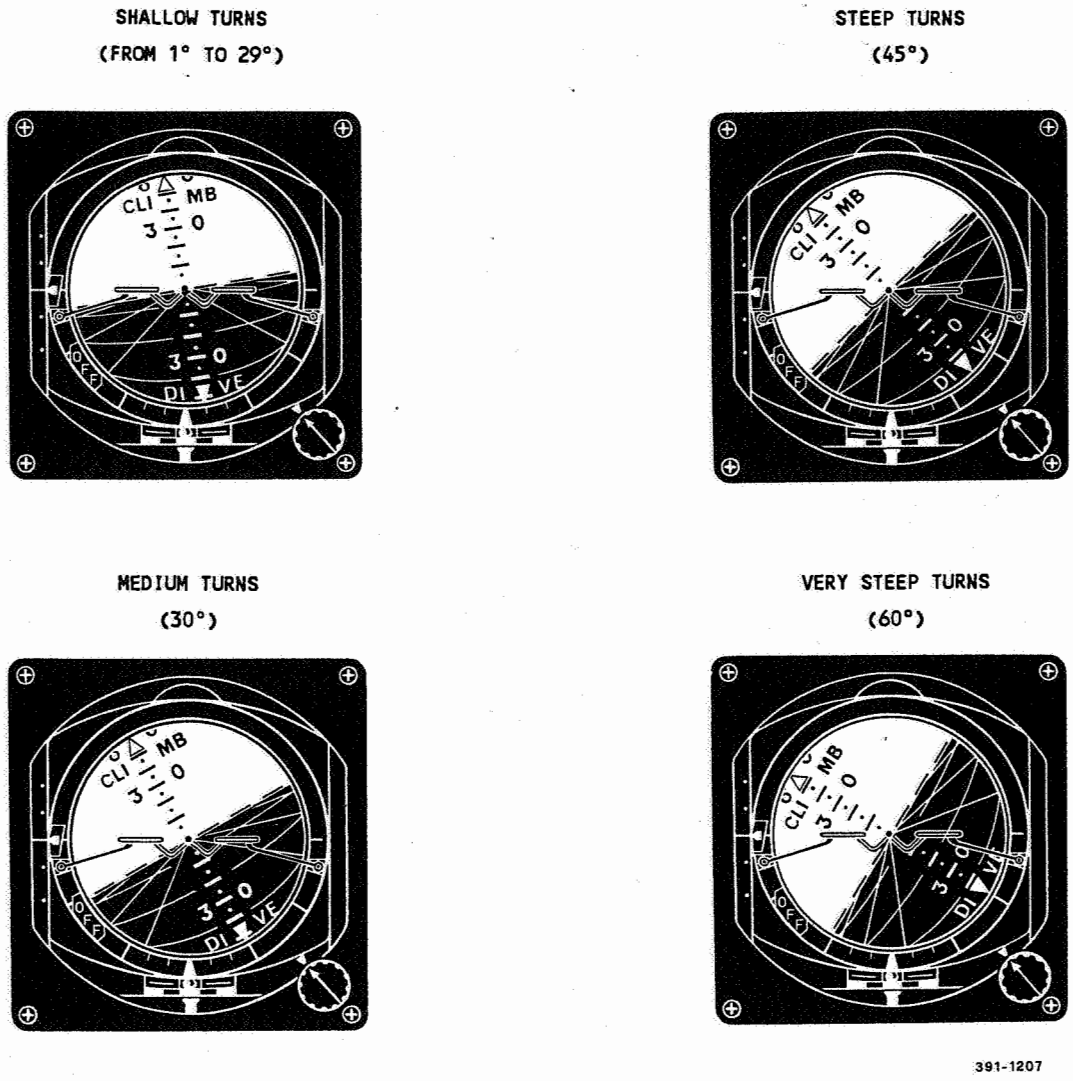


Figure 10-28. Instrument Turns

(1) Technique. The technique used to fly instrument turns is the same as that used when flying turns in visual flying. See chapter VI, paragraph 3.

(a) Shallow and medium turns

Performance

- Start the maneuver with the correct parameters
- When beginning the maneuver, pay special attention to the ADI and bank the aircraft in the desired direction and by the desired amount
  * For 30° turns, slightly increase the pitch on the ADI
  * Once attitude has been stabilized, carry out the normal cross--check
  * In presence of errors, implement the normal correction technique applicable to straight and level flight
  * During roll-out to take a given heading, start the maneuver with a lead of approx. 10° (1/3 of bank)

b. Steep and Very Steep Turns

(1) For steep and very steep turns, the performance technique is the same as used for medium turns, except for the following:

(a) When going beyond 30° of bank it is necessary to progressively increase back pressure on the stick (in proportion to the required bank angle) so as to keep the miniature aircraft center dot coincident with the horizon line on the ADI. At the same time, increase RPM to maintain airspeed constant. This increase is approx 3% for steep turns and 5% for very steep turns.

(b) The correction technique applicable to steep turns is identical to that used for medium turns. For very steep turns conversely, altitude errors are corrected by suitably changing the roll or pitch attitude: for instance, below the desired altitude, the wing bank angle must be decreased until a value of approx. 50° is attained without changing the back pressure applied on the stick. If conversely altitude is higher than required, it is sufficient to slightly relax back pressure on the stick while maintaining the 60° of bank. In both cases, after completing the correction, continue the turn with the required bank angle and back pressure on the stick.

(c) For recovery from both steep and very steep turns it is necessary to consider the required lead (1/3 of bank angle). When a bank angle of approx. 30° is approached, back pressure on the stick should be relaxed and engine setting brought back to the initial value.

(2) Considerations during the roll-in and roll-out phases, do not excessively concentrate your attention on the tilt of the horizon of the ADI so neglecting to monitor the pitch attitude.

(a) Memorize the required heading value on the compass card by use of the heading set knob.

(b) For turns covering a wide sector (ex. 180, 360°), initially skip over the HSI during cross-check to monitor the other performance instruments more closely

(c) Set recovery with the required lead in order not to overshoot the established heading

(d) If lead on recovery is excessive (heading values still to be reached), it will be necessary to retain a bank angle of 5° to 10° max until the desired value is attained.

(e) Conversely, if recovery is started too late, heading correction will be made by applying the already detailed technique.

c. Timed Turns in Straight and Level Flight

Timed turns are carried out during particular maneuvers and procedures in which the change of direction must be made with a well defined angular velocity (ex. holding pattern turns, reversal turns, etc.) in order to comply with the prescribed times and flight paths.
These turns are also flown in case of failure of the HSI.
Timed turns can be flown with two different turn rates, that is with two different angular velocities:

(1) 1/2 rate (fig. 10-29): corresponding to the turn needle touching the mark edge on the ADI turn and bank indicator (ω 1.5 deg/sec)

(2) 1 rate (fig. 10-30): corresponding to turn needle aligned with the mark on the ADI turn and bank indicator ω 3 deg/sec.

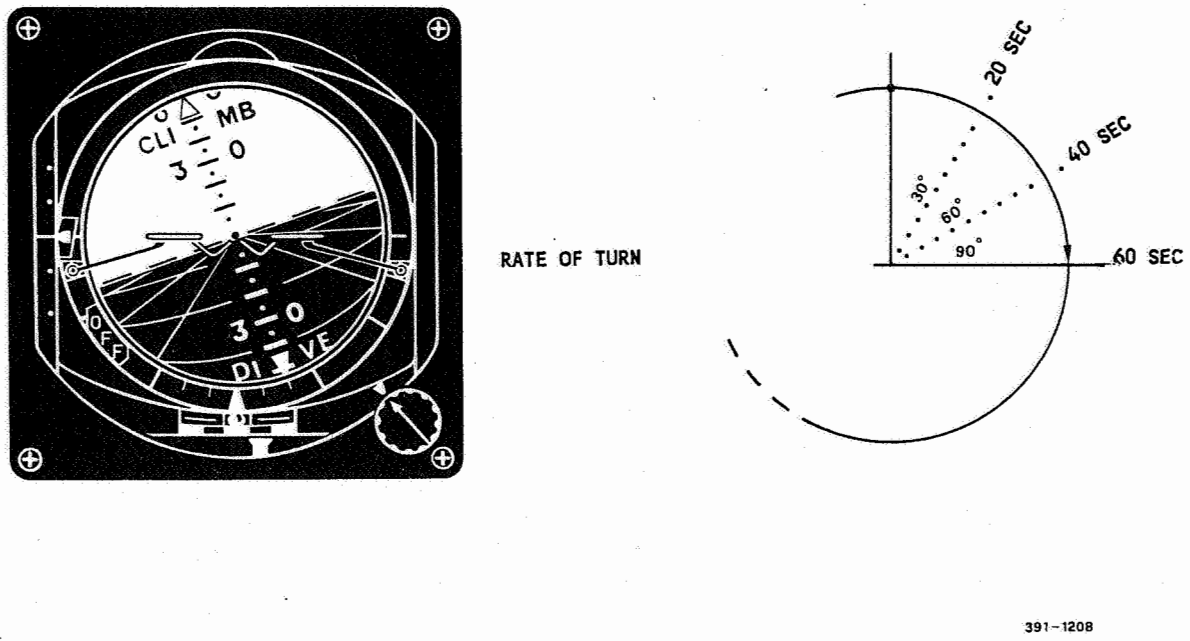


Figure 10-29. Turn With "1/2 Rate"

Instrument flying procedures have been envisaging for some years now that turns be flown with a bank angle of 30°, exception made for holding pattern timing reasons (extended pattern).
During timed turns the following must be borne in mind:

- In radio aided flight, timed turns are usually flown at rate 1 when this does not result in exceeding a bank angle of 30°.

- If the IAS and turn rate are kept constant, the aircraft bank angle will change because it is a direct function of the true airspeed (TAS), that increases or decreases along with altitude.

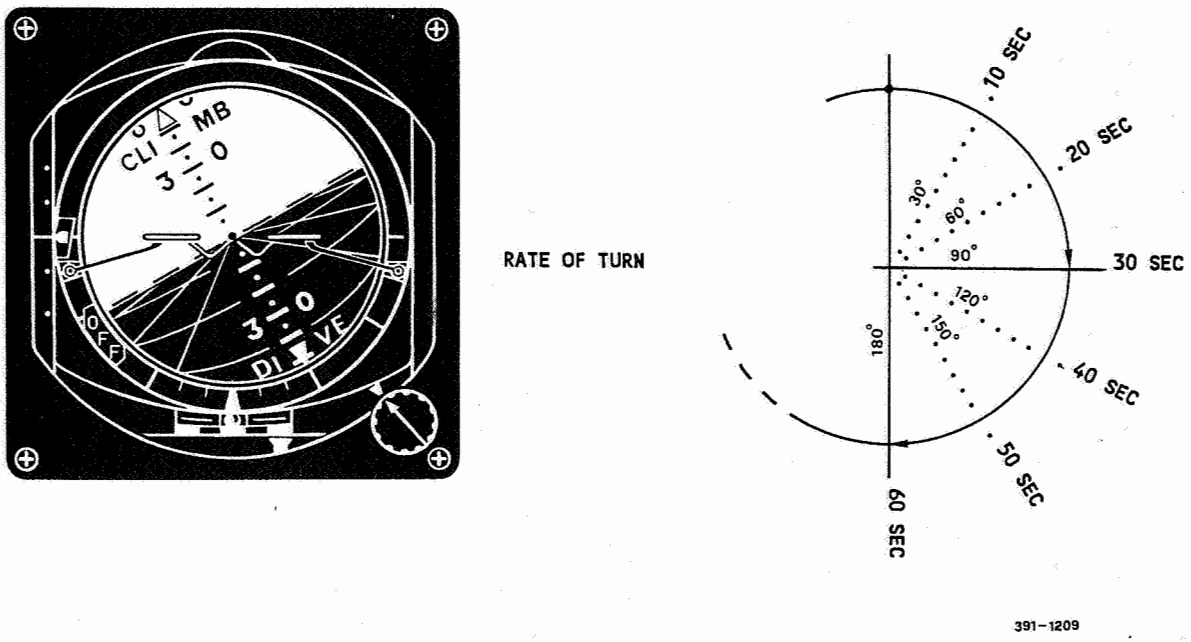


Figure 10-30. Turn With "1 Rate"

On the basis of the above, it is therefore suggested to adopt rates of ω = 1.5 deg/sec everytime the IAS exceeds 180 kts or when the concurrent IAS, altitude and temperature conditions make aircraft TAS exceed a maximum of 220 kts, thus limiting the bank angle to 30° (value not to be exceeded).
Since the airspeed indicator reads with the indicated airspeed (IAS) and not with the true airspeed (TAS), to simplify the calculations in flight, the following procedure will be adopted in practice:

- Below 10 000 ft, with IAS below 180 KIAS, turn with a turn rate of ω = 3 deg/sec

- Above 10 000 ft, with IAS above 180 KIAS, turn with a turn rate of ω = 1,5 deg/sec.

The so obtained value of ω will obviously be approximate. Figure 10-31 conversely establishes the rate of turn which should theoretically be maintained to hold the different altitudes and IAS with the greatest accuracy.
A TAS of 220 knots is the speed that requires that a bank angle of 30° be maintained to turn at a rate of 3 deg/sec, that is at rate 1.

(a) Performance

- Begin banking the aircraft and concurrently start the stop-watch;

- Bring the needle of the turn and bank indicator to the value corresponding to the selected rate of turn. Check the value of the attained wing bank angle on the ADI in order to keep it constant throughout the turn.

- When the envisaged time has elapsed (30 sec, 1 minute, 2 minutes, etc.) start roll-out as from a normal turn.

(b) Considerations

- The initial lag in the calculation of the turning time (due to the roll-in phase) will be recovered during roll-out.

- Do not excessively concentrate attention on the clock, HSI and turn and bank indicator, thus neglecting the general conduct of the flight.

- With the HSI in operation, to verify that the angular velocity actually corresponds to the chosen rate of turn, carry out intermediate checks of the elapsed time and flown degrees. This permits the required corrections to be made by suitably changing the bank angle.

- Do not make too wide corrections of the bank angle.

- To check the longitudinal attitude, for the use of power and trim, the same considerations apply as specified for the turns flown on the gyro-compass.

d. Use of the FDS (Flight Director System) to Fly Instrument Turn

Timed turns can be flown in level flight by referring to the ADI horizontal steering bar only, depressing the ALT HOLD push-button of the FDS at the desired altitude so that altitude is held and pitch attitude maintained.
Roll attitude must conversely be maintained by observing the ADI earth sphere and the turn needle.
Only medium turns with a bank angle of 30° at constant altitude can be flown exclusively by reference to the steering bars, viz. horizontal bar (to hold altitude) and vertical bar (to attain and hold 30° of bank and to establish the required lead on wing level-off).
The procedure is as follows:

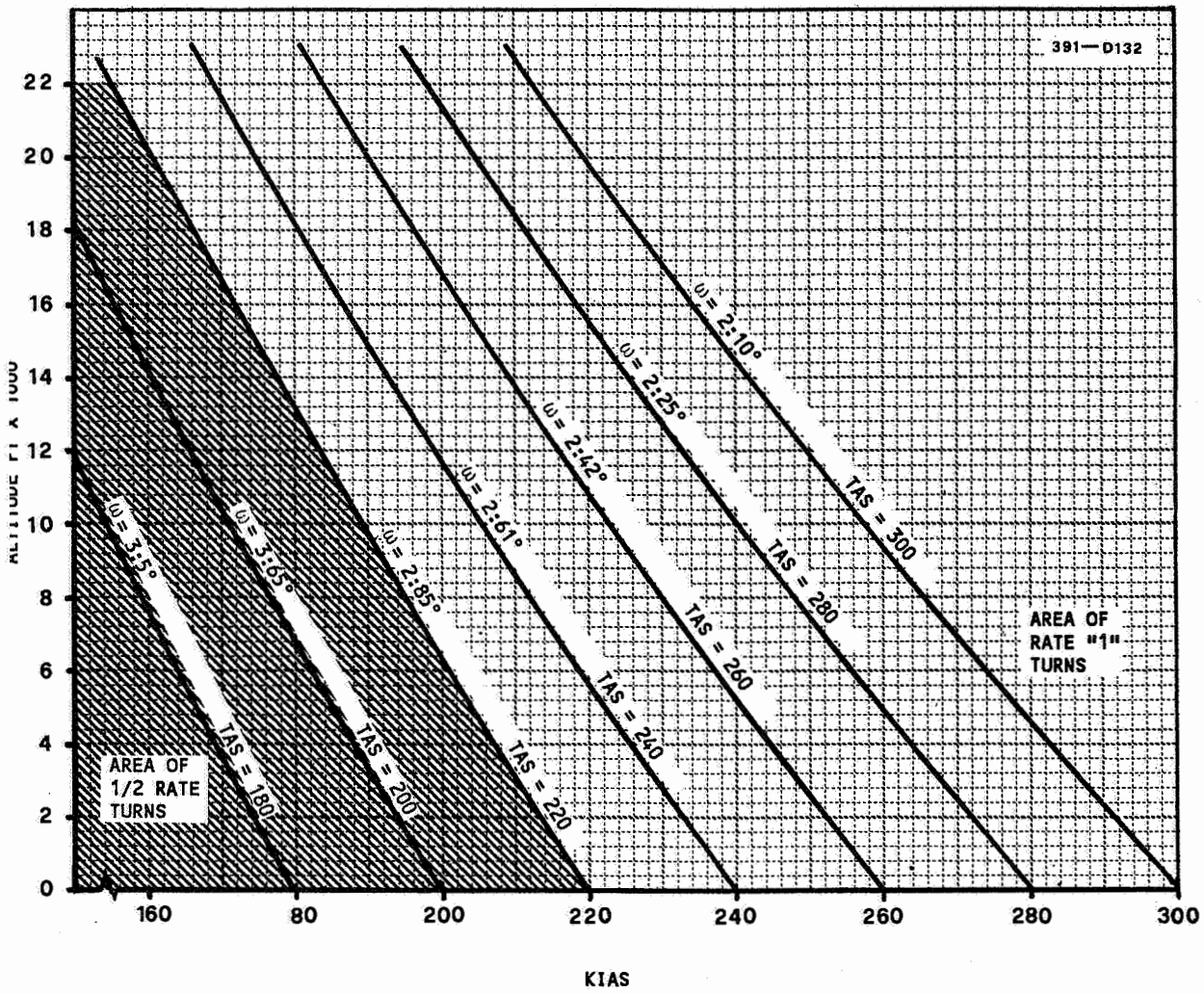


Figure 10-31. Turns at 30° Bank and Different IAS and Altitudes

(1) Make sure that the "NAV" push-button light on the "CONTROL SHIFT" panel is on.

(2) By rotating the "HEADING SET" knob on the HSI, bring the heading pointer to the desired value.

(3) Press the "HDG" push-button on the "FLT DIR" control panel.

(4) Check altitude and when the altimeter exactly indicates the desired altitude, press the "ALT HOLD" push-button on the "FLT DIR" control panel.

(5) Follow the horizontal and vertical steering bars with istinctive and smooth movements of the control stick.
The aircraft will fly the turn at a constant altitude and will terminate the turn with a smooth roll-out, exactly on the desired heading.

No other actions are required on the "FLT DIR" control panel to maintain the new heading.

e. Descending and Climbing Turns on the Gyro Compass or Timed Turns

For descending and climbing turns, the same procedures apply as for turns on the line of flight, except for the fact that they are flown with constant IAS or vertical velocity values.

7. SPEED CHANGES

a. General

These maneuvers are very useful during instrument flying because, especially during radio aided flight, there is a number of situations requiring that speed be changed.
These changes are needed to bind together the different phases of an instrument flight, to improve the cross-check technique and to accustom the pilot to mentally process the data inherent in the parameters required to fly the subsequent maneuvers.

IAS changes can be made:

- In straight and level flight
- During turns with constant rate of turn
- During turns with constant bank angle
- During climb or descent

b. Speed Variations in Straight and Level Instrument Flying

Comply with the prescriptions specified in Chap. VI, Para. 4, of this manual.

(1) $\Delta V \leq 30$ knots

(a) Increasing

- Increase the initial power setting by 1% every 10 kt of required airspeed increase
- Add a temporary 5% RPM to the so obtained power setting
- With a small lead on the desired IAS, retard the throttle to remove the temporarily added 5% RPM

(b) Decreasing

- Subtract 1% RPM from the initial power setting for every 10 kt of required decrease in speed
- Temporarily subtract 5% RPM to the so obtained RPM
- With a small lead on the desired IAS, advance the throttle to restore the temporarily removed 5% RPM

(2) $\Delta V > 30$ kt

(a) Increasing

- Mentally calculate the new % RPM (+ 1% every 10 kt of required variation)
- Apply 100 % RPM
- With a lead of 5 kt on the desired IAS, return power setting to the previously computed value

(b) Decreasing

- Mentally calculate the new % RPM (-1% every 10 kt of change)
- Retard the throttle to the so calculated power setting and extract the speedbrake
- With a small lead on the envisaged IAS, retract the speedbrake

c. Speed Variations during Turns with Constant Rate of Turn ω

- The procedure conforms to the previous indications

- As already pointed out for timed turns, if turn is intended to be flown with constant IAS and ω, but with increasing altitude, it will be necessary to change the wing bank angle. Ex. to turn at constant IAS and ω but gaining altitude, it will be necessary to increase the wing bank angle as shown in the figure 10-32.

NOTE

It is pointed out that the previously calculated RPM shall be slightly increased with respect to the RPM calculated for the variations in level flight

d. Considerations

- It is important to timely determine the new power setting as a function of the required IAS

- In all cases, once the desired speed has been attained, suitably adjust the trims to adjust stick forces

- Small airspeed variations correspond to small displacements of the miniature aircraft on the ADI

- If the difference between the initial airspeed and the final speed is conversely remarkable, and the new parameter is to be maintained for a long period, it will be advisable to move the horizon line and bring it to coincide with the miniature aircraft by acting on the special adjustment knob, this permits a more precise reading of the ADI to be obtained.

- Consider that an adjustment of the power upon maneuver completion may be required to maintain the new airspeed. It is in fact reminded that

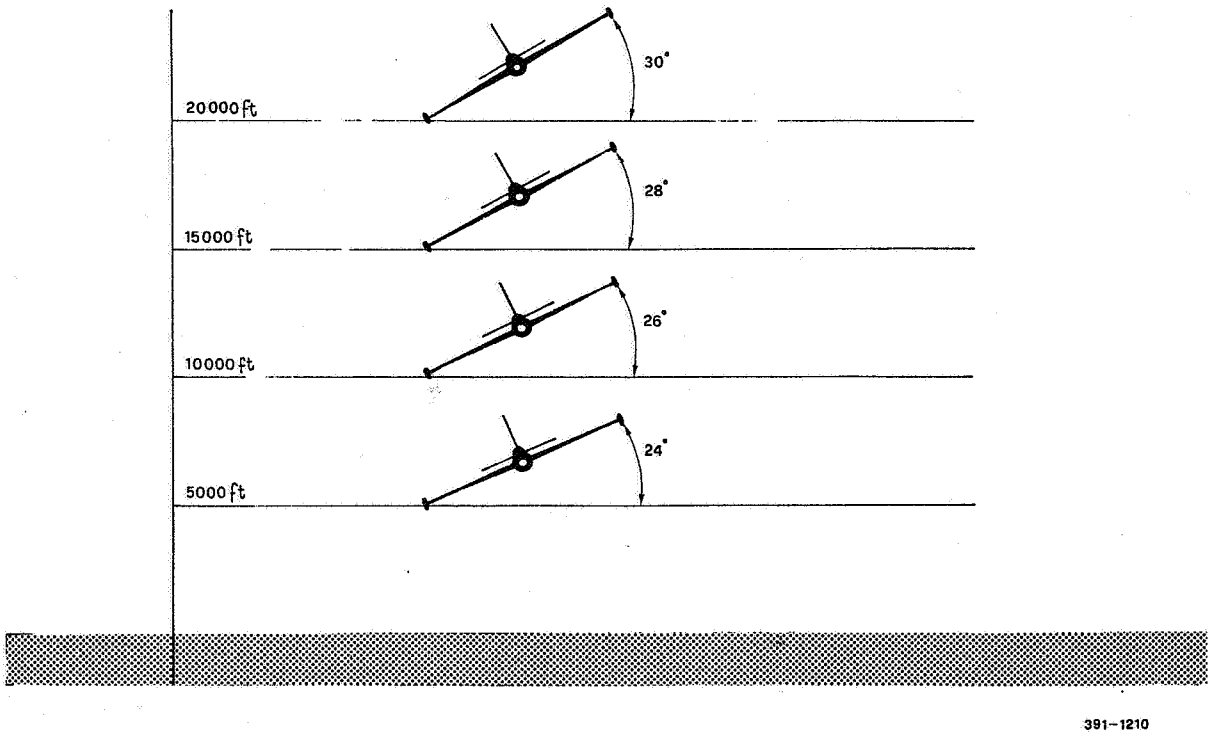


Figure 10-32. Constant IAS and Constant ω Turns

the previously calculated changes of the power setting may undergo further adjustments especially in presence of wide airspeed variations, since the ensuing changes of pitch attitude modify the aircraft drag and thus the required power setting.

e. RPM Changes as a Function of Vertical Speed

The RPM changes as a function of vertical speed when the IAS must be held constant have already been described in Chap. VI, Para 5 of this publication.

f. IAS Changes in Climb and Descent

It is possible to have a concurrent change in IAS and vertical speed: in this case action is to be taken by combining the procedure to point b with that to point e.
For instance, if it is desired to climb with a climb rate of 500 ft/min and increase the IAS by 10 kts, the RPM shall be increased by 1% to account for the 10 kts increase and by 4% for climb. On the whole this means a RPM increase of 5%. Once the desired IAS is attained (in straight and level flight), gradually pitch the aircraft up until the desired rate of climb is attained and maintained.

8. SLOW INSTRUMENT FLIGHT

a. General

Flying according to the parameters listed hereafter aims at familiarizing the pilot with the low speed techniques to be used in instrument flying.

- In slow flying, it is extremely important that the rudder pedals and trims be correctly used for proper coordination.

- Bear in mind that controls are looser when IAS decreases, and thus wide and unusual stick movements are necessary to change attitude.

- Thrust variations resulting from power setting variations (applied for the setting and configuration typical of the maneuver), are affected by a remarkable inertia; the pilot must therefore PLAN ANY ACTION BY SUITABLY CHANGING POWER SETTING WITH A LEAD.
This type of flight can be accomplished both in cruise configuration (aircraft clean) and in landing configuration (aircraft with landing gear and flaps down)

b. Slow Straight and Level Flight

(1) Performance
- Entry: refer to the decreasing speed changes; once the envisaged speed is attained, maintain it and refer to the AOA indications for confirmation that aircraft attitude is correct.

- Recovery
Refer to increasing speed changes

(a) Slow level flight (cruise configuration)

- IAS : 170 Kt

- RPM : as a function of altitude: approx. 80% RPM at 20 000 ft, approx 70% RPM at 1500 ft

- AOA: approx 0.30

- Maximum bank angle: corresponding to 3 deg/sec

(b) Slow flight (landing configuration) (level flight)

- At a speed equal or slower than 175 KIAS, landing gear down and speedbrake up

- Flaps: T/O

- IAS 130 kt

- RMP as a function of altitude: approx 91% RPM at 20 000 ft, approx 81% RPM at 1500 ft

- AOA equal to or smaller than 0.43

- Maximum bank angle: corresponding to 1,5 deg/sec

(2) Considerations

- When approaching the envisaged speeds, promptly act on the engine to avoid reaching too low speeds.

- Bear in mind that when speed decreases it is necessary to increase pitch attitude monitoring in order not to incur in altitude errors that might be of large extent.

- Enter reading of the AOA in the instrument cross-check to confirm that flight attitude is correct

- For very small heading changes, act on the rudder pedals to slightly change the aircraft direction.

- Avoid exceeding a bank angle of 15° to 20° above all when flying in landing configuration

- Carry out the checks prescribed after lowering/retraction of the landing gear and flaps and suitably use the trim

c. Slow Descending Flight (Landing Configuration)

This maneuver is propaedeutic to the performance of the final phases of the radio-aided instrument approaches and summarizes the already described slow flight technique.

(1) Performance

After reaching the slow flight conditions in cruise configuration (170 KIAS, AOA approx 0.30), proceed as follows:

- Lower the landing gear

- Lower the flaps to the T/O position and continue holding altitude

- When a IAS of 130 kt is attained, maintain it (RPM = approx. 82%)

- With a small lead on the descent starting point, set the flaps to DN and wait, at constant altitude, that speed decreases to 115 KIAS plus corrections

- Lower the aircraft nose and by suitably acting on power setting (approx. 78% RPM at 1500 ft), maintain 115 kt plus correction; (AOA equal to approx 0.45), and a vertical speed of 500 to 600 ft to descend.

- Carefully trim the aircraft.

(2) Considerations

- Carry out the checks prescribed after landing gear and flap lowering

- When starting the maneuver, carry out a small attitude variation to commence descent

- During descent increase frequency of cross check

- Take action to correct the pitch errors by changing attitude little by little

- When flying wide turns, do not exceed 15° of bank (3 deg/sec), while for small heading variations (2° or 3°), act on the rudder pedals rather than on the stick

- It is pointed out that the aircraft must be correctly trimmed during descent.

NOTE

To level-off after this type of descent, apply the technique envisaged for normal level-off. In case of level-off at the same speed as descent (115 KIAS), action on engine setting should be timely to avoid reaching airspeeds close to the stall airspeed.

9. INSTRUMENT DESCENTS AND LEVEL-OFF AFTER DESCENT

a. General

- Before starting any instrument descent from the assigned level, request the necessary clearance and QNH to the concerned Air Traffic Control activity

- When starting a descent envisaging level-off at an altitude lower than the transition height, it is necessary to set the altimeter on the QNH.

b. Descent with Constant IAS (fig. 10-33)

When comparing the IAS of straight and level flight at altitude and the IAS of descent the following cases may be identified:

- Descent IAS equal to initial IAS
- Descent IAS greater than initial IAS
- Descent IAS lower than initial IAS

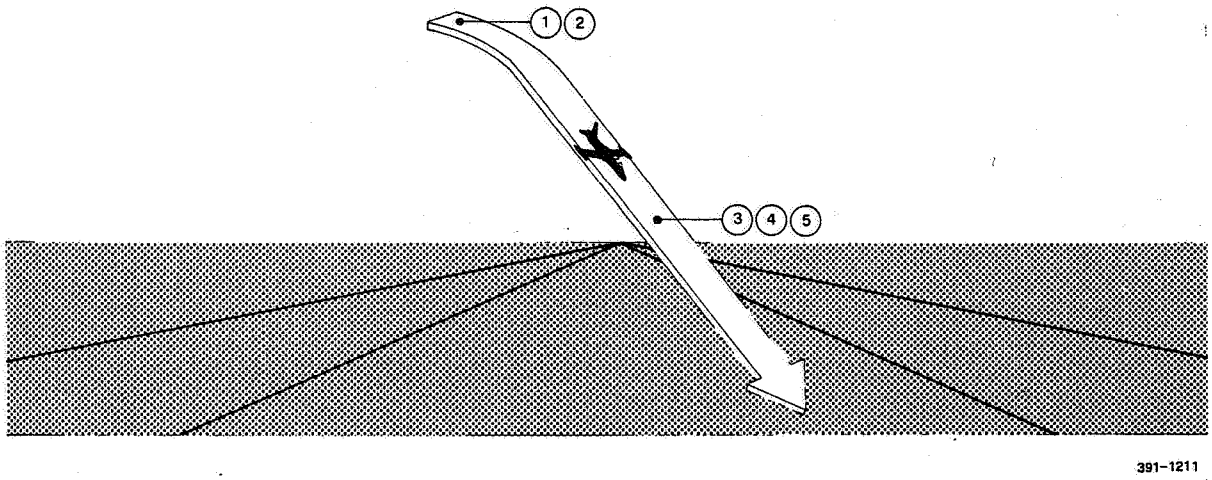
(1) Normally, when levels are changed, the type of descent flown is the one in which the descent IAS is equal to the initial IAS. After accomplishing the envisaged checks, descent is started by setting power to 60% RPM and concurrently changing the pitch attitude of the aircraft to maintain the initial IAS, which corresponds to Mach 0.55

(2) If descents are flown at constant IAS and with a specified vertical speed (ex. 1000 ft/min in changes of level) the aircraft nose must be lowered as a function of vertical speed and RPM reduced as specified in paragraph 7.d.

(3) For the other instances mentioned at the beginning of this paragraph, refer to visual descents.

(4) Descent is to be flown by referring to the attitude indicator, which is the CONTROL INSTRUMENT in this case, while the used PERFORMANCE INSTRUMENTS are the airspeed indicator to maintain speed, the gyrocompass to monitor heading, the vertical speed indicator to monitor the rate of descent and the altimeters to assess the subsequent vertical positions.

(5) The use of the speedbrake is at pilot's discretion. He will consider the velocity with which he wants or has to fly the descent.



1. MACH 0.55, ADI READING: LEVEL IN PITCH AND ROLL
2. REDUCE POWER TO 60% RPM, AT THE SAME TIME GENTLY BRING THE NOSE-DOWN TO APPROX. 10° ON THE ADI
3. CHECK THAT IAS REMAINS CONSTANT. IF REQUIRED, MAKE SMALL ATTITUDE CORRECTIONS
4. CROSS-CHECK ADI, AIRSPEED INDICATOR, HSI FOR HEADING
5. RESTORE 60% RPM

Figure 10-33. Instrument Descent at Constant IAS

(6) It is advisable to adjust the trims to allow the new attitudes to be easily maintained.

NOTE

- During instrument descent it is possible to fly turns; however a wing bank angle of 30° must not be exceeded when turning.
- It is pointed out that it is often necessary to restore the chosen RPM since it diminishes with the altitude decrease.

c. Penetration Type Descent (fig. 10-34)

It is the type of descent which is flown during instrument procedures

(1) Performance: carry out the pre-descent checks at least 5 minutes before descent is initiated.

- Inform the air traffic control (with which you are in contact) that you intend to leave your flight level

- Enter the QNH advised by the APP in the altimeter only if no level-off is envisaged above the transition height

- Reduce power to 76% RPM

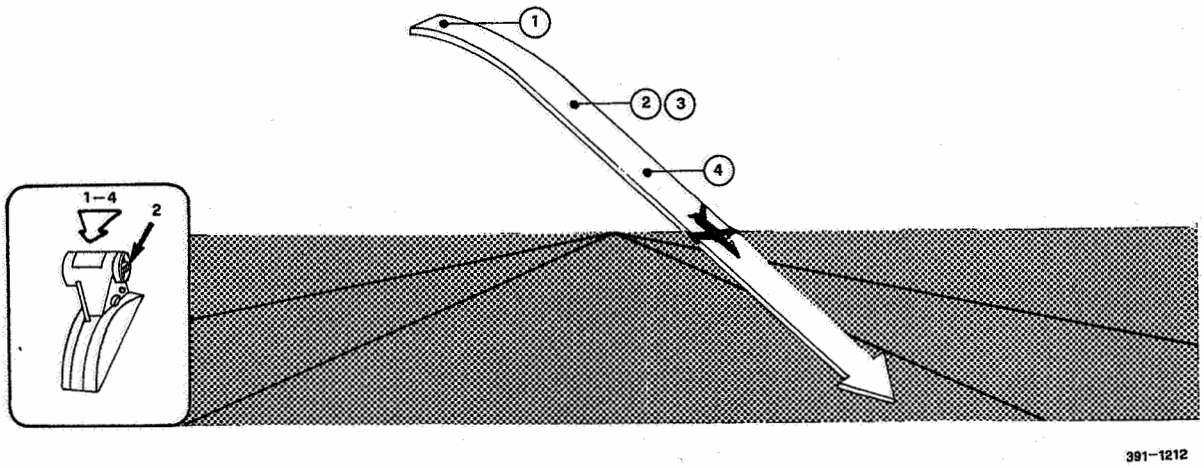
- By referring to the ADI, lower the aircraft nose by approx 12°

- With a speed close to 250 KIAS (with a lead of approx. 5 kt), lower the speedbrake

- While maintaining the IAS constant, trim the aircraft as required for the new configuration

- Restore the power setting during descent.

- Below 8000 ft check cabin altimeter and hydraulic pressure gauges



1. REDUCE RPM TO 76%, LOWER THE NOSE APPROX. 12° BY REFERRING TO THE ADI, CHECK HEADING
2. AT 245 KIAS EXTEND THE SPEEDBRAKE
3. AT 250 KIAS STABILIZE BY REFERRING TO THE ADI, TRIM
4. RESTORE RPM TO 76% IN DESCENT, CROSS-CHECK ADI, HSI AND AIRSPEED

Figure 10-34. Penetration

- Approx. 2000 ft above the envisaged level-off altitude, reduce the nose down attitude by half by referring to the ADI (see level-off after descent)

(2) Considerations

- The pre-descent checks are extremely important for safety

- Before penetration it is in fact necessary to know:

* The quantity of fuel to decide, as a function of the meteo conditions, whether descent is to be flown, or immediate diversion to the alternate airport is necessary (this aspect will take up a remarkable importance in the subsequent phases of navigation and radio-aided flight)

* Hydraulic pressure values ensuring landing gear lowering with the normal procedure

* Reliability of ADI and HSI readings

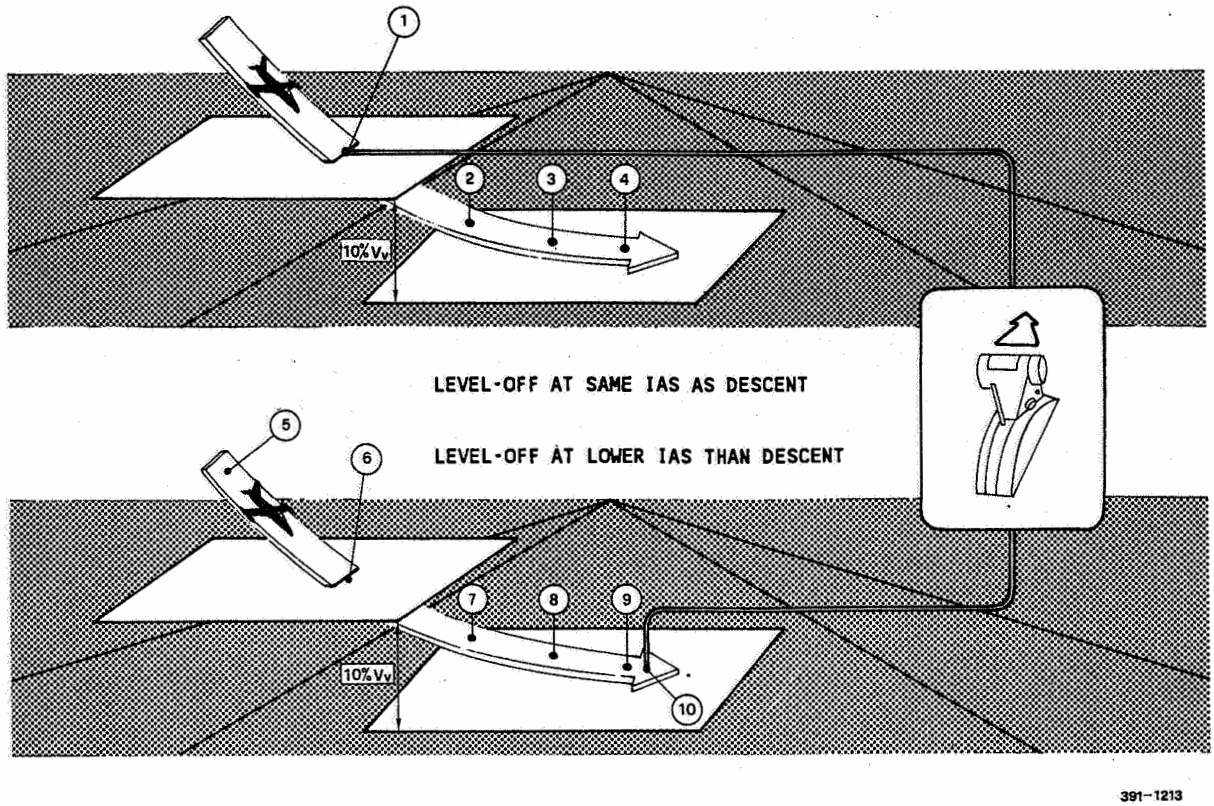
* The QNH to be entered at the correct moment. If this operation is omitted, minimum separation from obstacles is no longer guaranteed during final approach (radio aided flight).

- During corrections, bear in mind that any attitude change on the ADI result in a slower reading change on the Mach-airspeed indicator (delay in attaining the envisaged IAS).

- When approaching the level-off altitude, increase the frequency of instrument cross-check, paying special attention to the altimeter.

d. Level-off after Descent (fig. 10-35)

The procedure to be enforced depends upon the airspeed envisaged at the end of descent.
Two instances are possible:



1. 10% LEAD WITH RESPECT TO VERTICAL VELOCITY, SPEEDBRAKE IN, SLOWLY INCREASE RPM, START PULL-UP (REFER TO ADI) OBSERVING SYMBOL POSITION BELOW THE HORIZON
2. MOVE ADI SYMBOL TO AN ATTITUDE HALF OF PREVIOUS ATTITUDE
3. ADJUST RPM AS REQUIRED FOR LEVEL FLIGHT
4. TRIM
5. 2000 ft HIGHER THAN LEVEL-OFF ALTITUDE, HALVE VERTICAL VELOCITY BRINGING THE ADI AIRCRAFT SYMBOL TO A NOSE-DOWN ATTITUDE WHICH IS HALF OF THE PREVIOUS ONE
6. WITH A LEAD OF 10% ON INITIAL VERTICAL VELOCITY, START THE LEVEL-OFF MANEUVER
7,8. CROSS-CHECK OF ALTITUDE AND VERTICAL VELOCITY. CHANGE ATTITUDE ON THE ADI SO THAT VERTICAL VELOCITY BECOMES TEN TIMES THE ALTITUDE TO LOOSE
9. LEVEL-OFF AND TRIM AT REQUIRED ALTITUDE, ALLOW IAS TO DECREASE
10. WITH A 5-KNOT LEAD ON THE REQUIRED KIAS, RETRACT THE SPEEDBRAKE AND ADJUST RPM TO HAVE THE REQUIRED IAS AT THE LOW ALTITUDE

Figure 10-35. Level-off

- Level-off at the same airspeed as descent
- Level-off with final IAS lower than descent IAS

(1) Level-off at same IAS as descent

(a) Performance

- Start changing attitude with a lead of 10% with respect to vertical speed; concurrently retract the speedbrake and increase thrust by bringing RPM to the value required to maintain the airspeed constant at that altitude

- Trim the aircraft when maneuver is complete

(2) Level-off with final speed lower than descent speed. This level-off procedure is the procedure usually adopted after a penetration type descent. Since penetration is flown at a high vertical speed and level-off is performed at rather low altitude, apply the following procedure:

(a) Performance

- Approx. 2000 ft above the altitude to be reached, decrease descent rate by half by suitably changing attitude on the ADI

- Apply the known 10% lead on the envisaged altitude (approx. 200 ft above the altitude to be reached), start the final level-off maneuver

- Maintain altitude constant and allow speed to decrease

- With a slight lead on the envisaged altitude (170 KIAS), retract the speed brake and reduce power setting to approx. 70%

- Maintain speed constant at 170 KIAS (AOA approx. 0.30) and suitably trim the aircraft.

(b) Considerations

- When approaching the level-off altitude, increase the frequency of the instrument cross-check paying special attention to the altimeter

- Once 170 KIAS are attained, adjust the ADI by superimposing the horizon line onto the miniature aircraft to facilitate monitoring of the longitudinal attitude

- Pay special attention to the control of speed and AOA in order to avoid taking attitudes and entering conditions that might become critical

10. CLIMBS AND DESCENTS AT CONSTANT VERTICAL SPEED

a. General

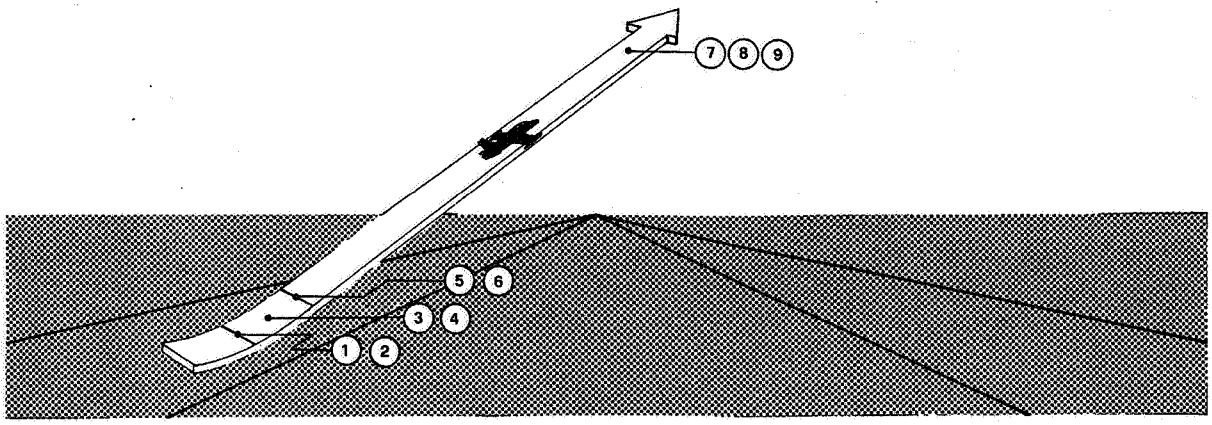
The basic instrument flying is aimed at making the coordination of attitude/power maneuvers nearly automatic.
The best results are obtained through familiarization maneuvers that attain the purpose even if they will not be applied during the normal navigation in IMC.
These maneuvers entail precise altitude variations while constant VERTICAL SPEED and IAS parameters are maintained.

b. Climb at Constant Vertical Speed (fig. 10-36)

Establish the vertical speed parameters and the indicated airspeed to be complied with. While maintaining the IAS constant, smoothly and concurrently change pitch attitude and power setting to bring the vertical speed to the desired value. During attitude variations, the control instruments are the ADI and the RPM indicator, while the performance instruments are the vertical speed indicator, the airspeed indicator and the HSI.
Once attitude has been stabilized, pilot's attention is to be devoted to the performance instruments; the control instruments shall be observed only to determine the need for possible corrections.
The maneuver can be flown while turning as well, and in this case, the performance instruments to monitor roll attitude will be the ADI and the turn and bank indicator (fig. 10-37).

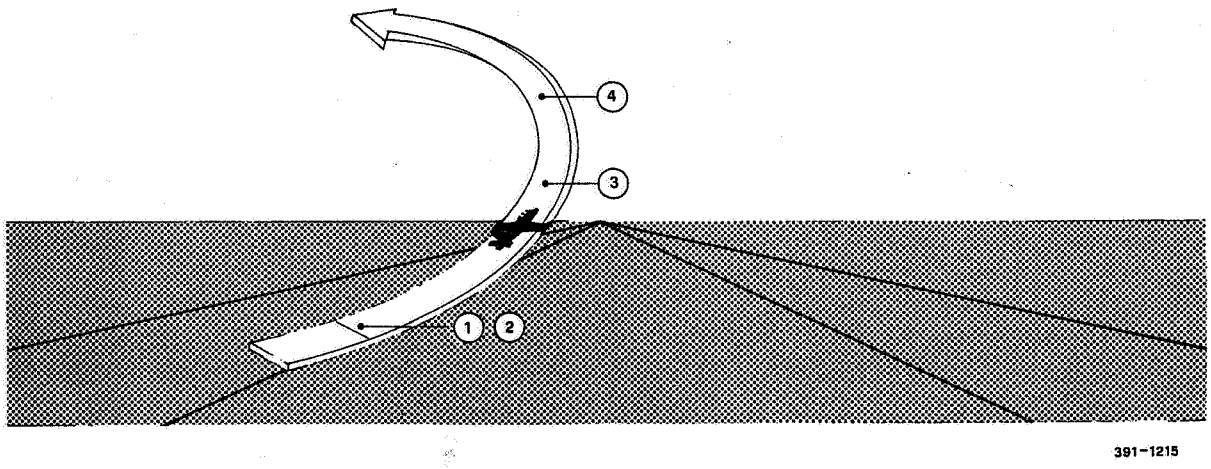
c. Descent at Constant Vertical Speed (fig. 10-38)

Establish the vertical speed and indicated airspeed parameters to be adhered to.
While maintaining the IAS constant, concurrently change the pitch attitude and power setting to bring the vertical speed to the desired value.
The control and performance instruments are the same as for climb.
The same modalities as previously detailed apply to turns. The final flight portion, both in climb and descent, is level-off, for which the same procedures apply as detailed above (fig. 10-39).



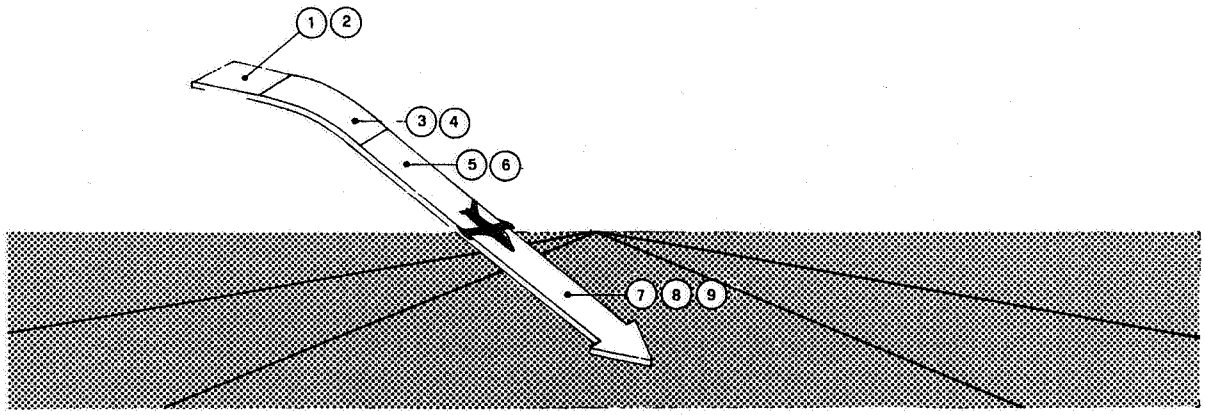
1. ADI - AIRCRAFT LEVEL
2. CHECK IAS, RPM, ALTIMETER, VERTICAL VELOCITY INDICATOR (READING ZERO), HSI (ENVISAGED HEADING)
3. SLOWLY AND CONTINUOUSLY INCREASE RPM AND PITCH
4. CHECK THAT IAS IS CONSTANT. THE VERTICAL VELOCITY INDICATOR SETS TO THE REQUIRED VERTICAL VELOCITY
5. STABILIZE RPM WHEN THE VERTICAL VELOCITY INDICATOR READS THE REQUIRED VALUE AND IAS IS AS NECESSARY
6. CHECK HEADING. WAIT A FEW INSTANTS AFTER ADJUSTING POWER SETTING AND/OR ATTITUDE TO OBTAIN STABILIZED IAS AND VERTICAL VELOCITY
7. CHECK HEADING. CHECK IAS AND VERTICAL SPEED
8. CARRY OUT RPM AND ATTITUDE CHANGES OF VERY SMALL MAGNITUDE
9. READ STABILIZED IAS AND VERTICAL VELOCITY, CONTINUE TO PERFORM THE REQUIRED CORRECTIONS

Figure 10-36. Straight Climb With Constant Vertical Velocity and Airspeed



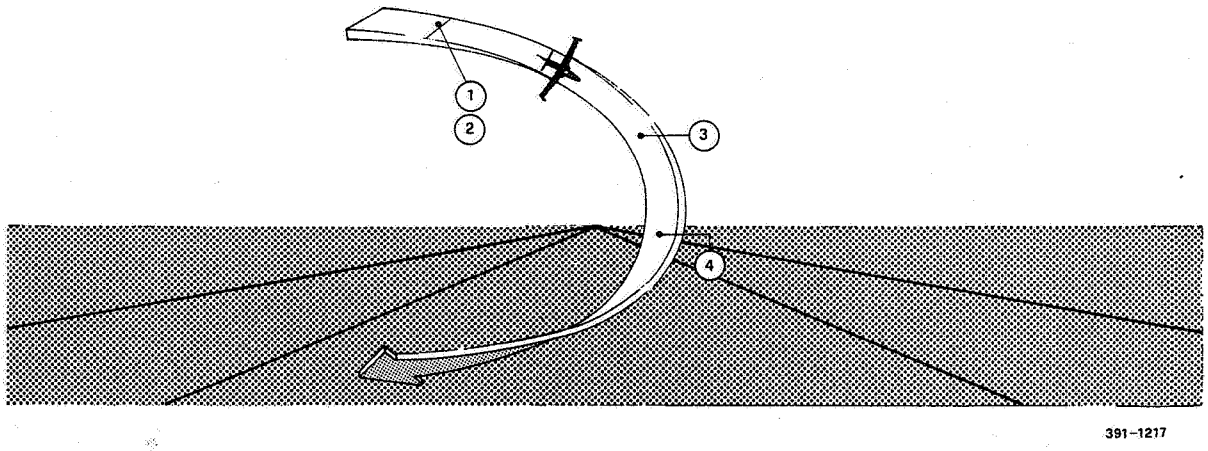
1. ADI: AIRCRAFT IN STRAIGHT AND LEVEL FLIGHT. CHECK IAS, RPM, ALTIMETER STILL AND VERTICAL VELOCITY INDICATOR READING ZERO. ENVISAGED INITIAL HEADING (HSI)
2. PROGRESSIVELY INCREASE RPM AND PITCH ATTITUDE WHILE CONCURRENTLY BANKING THE WINGS UNTIL THE REQUIRED RATE OF TURN IS SHOWN ON THE TURN AND BANK INDICATOR (ω =1.5 SEC.). CHECK ADI, VERTICAL VELOCITY, IAS AND RPM
3. CHECK ADI FOR CORRECT TURN. ENVISAGED IAS AND VERTICAL VELOCITY MUST BE ATTAINED AND HELD CONSTANT
4. CHECK ADI AND TURN AND BANK INDICATOR FOR CORRECT TURN. CARRY OUT VERY SMALL ATTITUDE AND POWER SETTING CHANGES. AWAIT A FEW SECONDS TO HAVE IAS AND VERTICAL VELOCITY RESPONSE

Figure 10-37. Climbing Turn With Constant Airspeed and Vertical Velocity and Constant ω



1. CHECK LEVEL FLIGHT ON ADI
2. CHECK IAS, RPM, ALTIMETER, VERTICAL VELOCITY INDICATOR (READING ZERO), HSI (ESTIMATED HEADING)
3. PROGRESSIVELY REDUCE RPM, THEN CONTROL TO OBTAIN A DESCENDING ATTITUDE WITH WINGS LEVEL ON THE ADI
4. CHECK OF IAS AND VERTICAL VELOCITY. IF ONE IS TOO HIGH AND THE OTHER TOO LOW, CORRECT ON THE ADI ONLY, IF BOTH ARE TOO HIGH OR TOO LOW, ACT ON RPM AS WELL
5. STABILIZE RPM WHEN THE VERTICAL VELOCITY INDICATOR AND THE AIRSPEED INDICATOR READ THE REQUIRED VALUES
6. CHECK HEADING (LATERAL ATTITUDE). WAIT FOR A FEW SECONDS AFTER ADJUSTING POWER SETTING AND/OR PITCH TO HAVE STABILIZED IAS AND VERTICAL VELOCITY
7. CHECK HEADING, CHECK IAS AND VERTICAL VELOCITY
8. CARRY OUT VERY SMALL ATTITUDE AND VERTICAL VELOCITY VARIATIONS
9. READ IAS AND VERTICAL VELOCITY ONLY WHEN THEY HAVE STABILIZED
   CONTINUE WITH REQUIRED CORRECTIONS

Figure 10-38. Descent at Constant Airspeed and Vertical Velocity



1. ADI AIRCRAFT IN STRAIGHT AND LEVEL FLIGHT. CHECK IAS, RPM, ALTIMETER READING CONSTANT, VERTICAL VELOCITY INDICATOR READING ZERO. INITIAL ESTIMATED HEADING (HSI)
2. PROGRESSIVELY DECREASE RPM (APPROX. 12% LESS), AND PITCH (1 BAR WIDTH) BY CONCURRENTLY BANKING THE WINGS UNTIL ω=1.5° SEC IS READ ON THE TURN AND BANK INDICATOR
3. KEEP TURN CORRECT BY REFERRING TO THE ADI. THE REQUIRED IAS AND VERTICAL SPEED MUST BE ATTAINED AND HELD CONSTANT
4. CHECK ADI AND TURN NEEDLE ON TURN AND BANK INDICATOR TO ASCERTAIN THAT TURN IS CORRECT. AWAIT A FEW SECONDS TO HAVE IAS AND VERTICAL VELOCITY RESPONSE

Figure 10-39. Descending Turn With Constant Rate of Turn, Vertical Velocity and Airspeed

d. Considerations

During both climb and descent, it is rather common to chase the vertical speed indicator. As this instrument suffers from a lag, it is recommended to carry out the pitch corrections on the ADI by suitably evaluating the small displacements of the miniature aircraft with respect to the horizon line.

NOTE

Usually the climbs and descents of these types are flown at a vertical speed of 1000 ft/min (orientatively +8% RPM in climb and -12% RPM in descent, ADI ± 2,5°).

PART THREE - CHAPTER X

SECTION C - CONFIDENCE MANEUVERS

These are maneuvers that permit a continuous and careful instrument cross-check and the required actions on controls and power setting to be carried out with foresight also in conditions under which several parameters change, sometimes abruptly.

1. VERTICAL "S"

a. General

This exercise is simply a combination of CLIMB and DESCENT, which are described in paragraph 10.

- The vertical "S" is flown between two preset levels, 1000 ft of altitude apart. The attainment of each level coincides with the change from diving to climbing flight, and, depending upon the type of chosen S, also with the reversal of the turn

- The pitch attitude change imposes that a lead point be established (10% of vertical speed)

- In the types of "S" envisaging turn reversal, the instant at which the pitch attitude change is commenced coincides with instant at which turn is initiated. In these instances, control inputs must be coordinated, so that the line of flight is crossed at the preset altitude, with wings level and vertical speed indicator reading zero.
This coordination must persist until reversal is complete (concurrent attainment of the stabilized parameters envisaged for the subsequent segment of the maneuver)

- The straight and level flight IAS, corresponding to Mach 0.5, must be kept constant throughout the attitude changes

- Bank angle to be maintained (for the vertical S flown in turn) is 30°

- Vertical velocity is 1000 ft/min

- The approximate power settings are respectively 78% (in descent), and 91% (in climb).

NOTE

Before flying the maneuver in IFR, request the assignment of two flight levels to the responsible Air Traffic Control activity.

b. Constant Heading Vertical "S" (Type "A") (fig. 10-40)

When flying this maneuver, pitch changes between the two given levels must be accomplished maintaining constant the heading assigned by the instructor.
Performance (the maneuver is assumed to be commenced at the higher level)

- Lower the aircraft nose very gently taking a 3° nose down attitude on the ADI

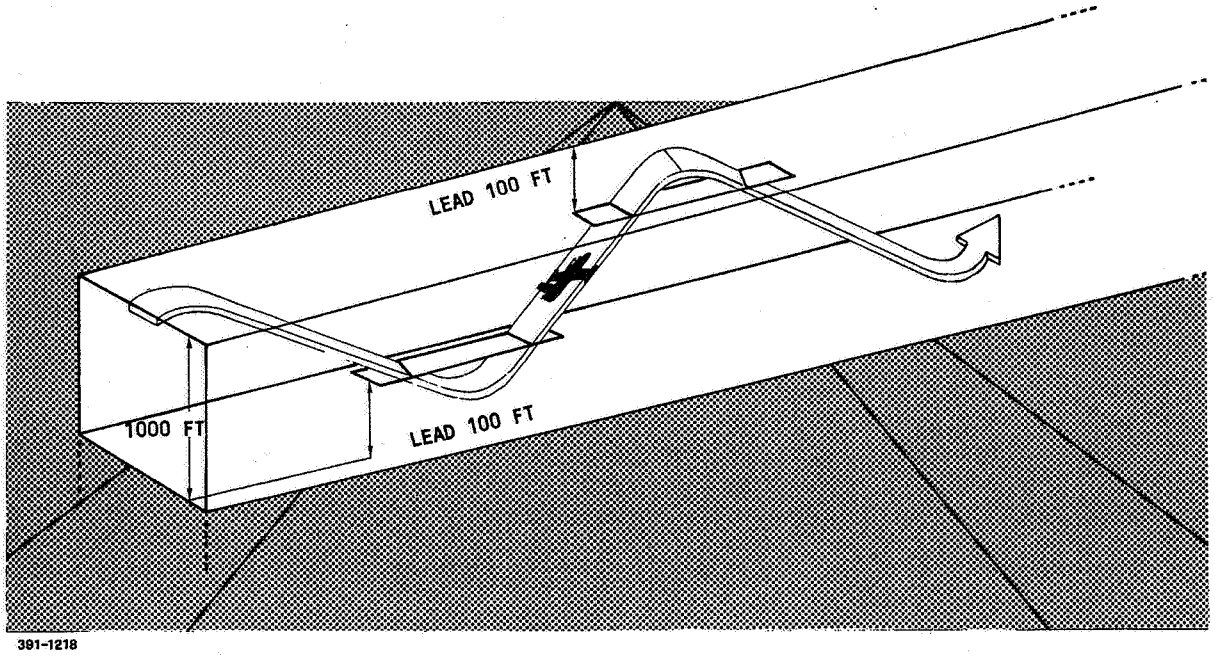


Figure 10-40. Vertical "S" With Constant Heading

- Concurrently retard the throttle (approx. 78% RPM) to maintain constant the IAS, which should correspond to Mach 0.5

- Check that the vertical velocity value stabilizes at 1000 ft in descent

- Carry out rapid cross-checks to maintain constant the IAS, heading and vertical velocity parameters

- With a lead of 100 ft on the lower level, start a smooth change of pitch attitude through level flight to reach a climb altitude; concurrently act on power setting (91%)

- Stabilize pitch attitude at a value of approx. 3° on the ADI and, implementing the applicable cross-check technique, maintain constant IAS, heading and vertical velocity (1000 ft/min in climb).

- With a lead of 100 ft on the upper level (altitude at which maneuver is started, and which is to be brushed), start a gradual pitch attitude change and reduce power setting to resume the flight conditions under which the previous dive was flown.

c. Type "B" Vertical "S" (fig. 10-41)

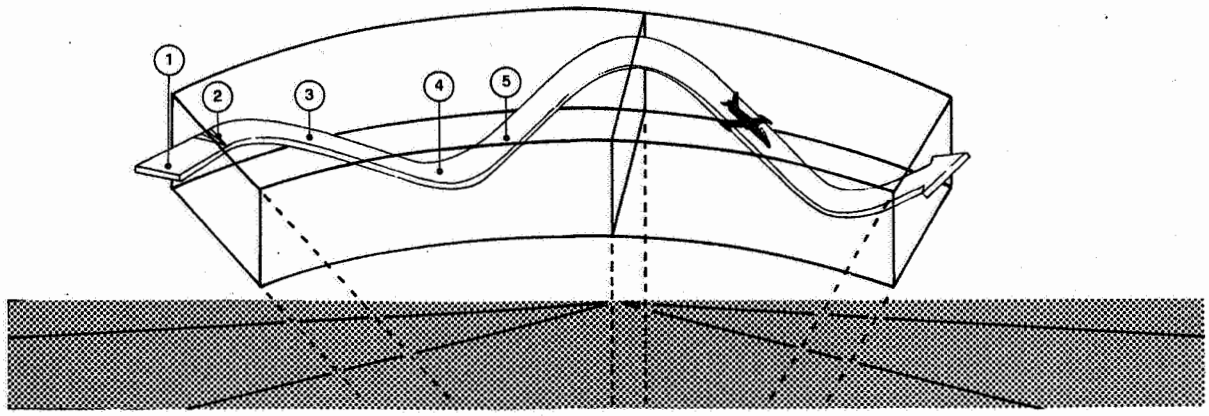
It is a maneuver to fly by maintaining constant the 30° bank attitude. Performance

- Smoothly lower the aircraft nose and concurrently bank the aircraft on the desired side

- Concurrently attain a bank angle of 30° and the envisaged dive attitude. This phase of the maneuver requires an accurate coordination of the controls; wing bank angle will remain constant throughout the maneuver

- As far as the performance is concerned, what specified for type A applies

- When the maneuver is complete, level the wings and start final level--off



1. STRAIGHT AND LEVEL FLIGHT AT MACH 0.50, FL 150
2. LOWER NOSE AND BANK RETARDING THE THROTTLE TO APPROX. 78%
3. VERTICAL VELOCITY STABILIZED AT 1000 FT/MIN TO DESCEND; IMN STEADY AT 0.50, WINGS BANKED 30°
4. AT 14100 FT, SLOWLY CHANGE PITCH ATTITUDE (FROM -3° TO +3°). WHILE CONCURRENTLY SETTING POWER TO APPROX. 91% RPM
5. STABILIZE 1000 FT/MIN TO CLIMB; IMN 0.50

Figure 10-41. Vertical Turns

d. Type "C" Vertical "S"

It is similar to the type "B" vertical "S", the only difference being the wing bank, which is to be reversed at the start of each cycle (usually when the second dive is commenced).
It is pointed out that, at the beginning of each cycle, and above all during roll reversal, the action on controls must be extremely smooth and coordinated.

e. Type "D" Vertical "S"

In this type of "S", the change in lateral attitude (turn reversal), takes place every half cycle, that is whenever dive or climb are commenced.
The same considerations as for the previous maneuvers apply.

NOTE

When flying types "C" and "D" vertical "S", there is the tendency to change attitude by reaching the desired pitch attitude first, and then the desired roll attitude. This is incorrect.

f. Considerations

- Start the maneuver with the exact parameters

- In the type "A" vertical "S", correct the heading errors with small roll attitude variations (10° max)

- During changes from climb to dive or viceversa, do not chase the vertical speed indicator, but refer to the ADI and evaluate the small changes it indicates; additionally, use power correctly to avoid IAS errors.

- Possible vertical velocity errors will be corrected with slight stick deflections (on the ADI), whilst IAS errors will be corrected with actions on power setting. Take into account the fact that the previously indicated RPM data are provided for guidance only, therefore, once the pitch attitude has stabilized, perform additional small power setting adjustments, if required.

- When turning in a vertical "S" pay special attention to coordination on the control so that the bank angle of 30° and the vertical speed of 1000 ft/min are concurrently attained.

- When the reversal altitude is being approached, act on the controls timely and with the required lead in order to reach precisely the two flight levels between which the maneuver is flown.

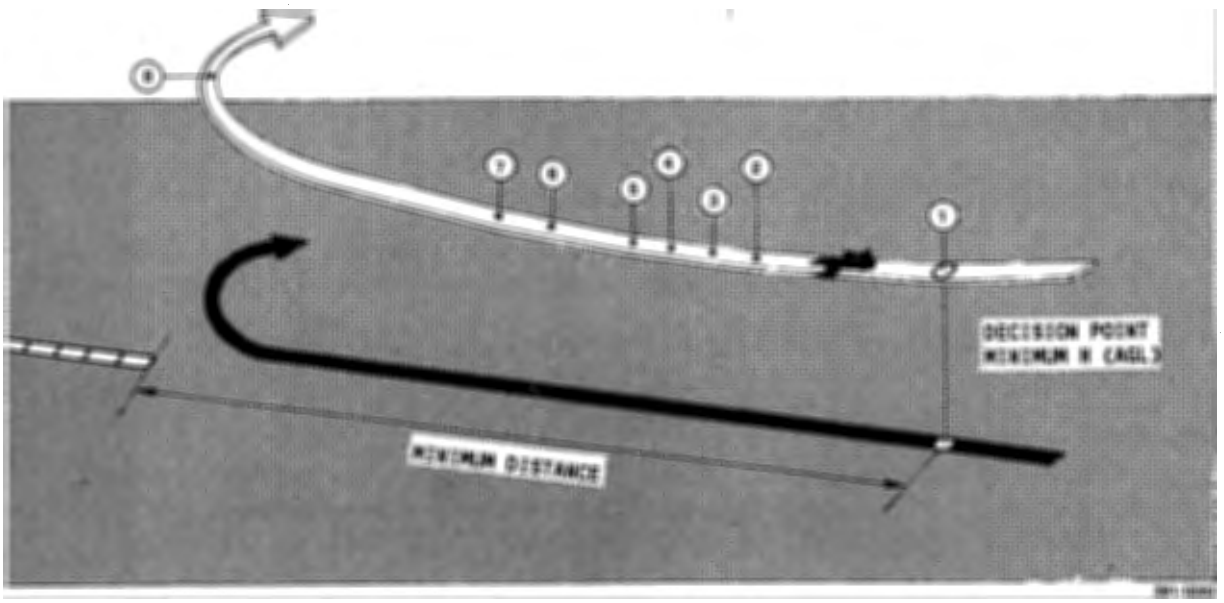
NOTE

Before accomplishing this maneuver it is required that the APP be requested to assign two flight levels.
Any type of vertical "S" is considered terminated after two descents and two climbs have been completed.

2. RECOVERY FROM SLOW INSTRUMENT FLYING (fig. 10-42)

a. General

This is a familiarization maneuver which simulates go around after a missed instrument approach. It permits to pass rapidly and in full safety from the slow flight conditions to the normal climb or straight and level flight conditions in clean configuration.



1. INFORM APPROACH OF DECISION TO GO AROUND
2. 100% RPM AND SPEEDBRAKE IN. CHECK RPM AND SPEEDBRAKE POSITION
3. HOLD ALTITUDE
4. LANDING GEAR UP
5. AT 120 KIAS, FLAPS UP
6. AFTER TAKE-OFF CHECKS
7. BRING THE AIRCRAFT TO NORMAL ACCELERATION ATTITUDE (ADI 8° POSITION, RATE OF CLIMB 1500 FT/MIN, AOA APPROX. 0.45, IAS INCREASING)
8. FLY PATH PESCRIBED BY LOCAL TRAFFIC PROCEDURES (SEE MISSED INSTRUMENT APPROACH PROCEDURE)

Figure 10-42. Recovery from Low Instrument Flying

Overshoot can be decided by the pilot for missed visual contact with the terrain at the approved minimums or because the alignment, heading, speed and altitude parameters have not been attained at the decision height.

b. Performance

(1) Inform APP as to the decision to go around

(2) 100 RPM and speedbrake in. Check thrust and speedbrake position

(3) Stop altitude

(4) Landing gear up

(5) At 120 KIAS, flaps UP

(6) After take-off checks

(7) Bring the aircraft to the normal acceleration attitude (8° nose-up on the ADI), then vertical speed will have to become 1500 ft/min, AOA approx. 0.45, and IAS to increase)

(8) Go around on the normal pattern established by the local traffic regulations.

See the MISSED INSTRUMENT APPROACH procedures.
Once the aircraft has started accelerating, the procedure is identical to the one applicable to the (instrument) acceleration phase after take--off.

3. UNUSUAL ATTITUDES (fig. 10-43)

a. General

- An unusual attitude could be defined as any unplanned and undesired attitude taken by the aircraft when flying a maneuver, and ascribable to different causes and reasons beyond the pilot's control. It is however advisable to restrict this definition to the most serious cases in which, in addition to the basic element of accidentally taking of a non-desired attitude, there comes along a second and more serious problem, that is the loss of aircraft control.
In fact, whilst in the first instance it is possible to have recourse to the normal correction technique, in the second case the following is essential: to identify the aircraft attitude by referring to the instruments first, and then take action by implementing the applicable recovery techniques.

- Some of the main causes that can determine loss of aircraft control are: strong turbulence, dizziness, pilot's lack of attention, piloting errors or wrong corrective actions, failure of airborne instruments

- The recovery techniques that will be described hereafter are based on the requirement to RECOVER the aircraft with the greatest possible safety, in the shortest possible time and with the smallest possible loss of altitude.

- Every recovery can be considered complete when aircraft control is resumed

- The return to the correct parameters, which is always essential, is obtained by enforcing the normal instrument procedures.

For training purposes, during the phase of basic instrument flying, unusual attitudes are "created" by the instructor.

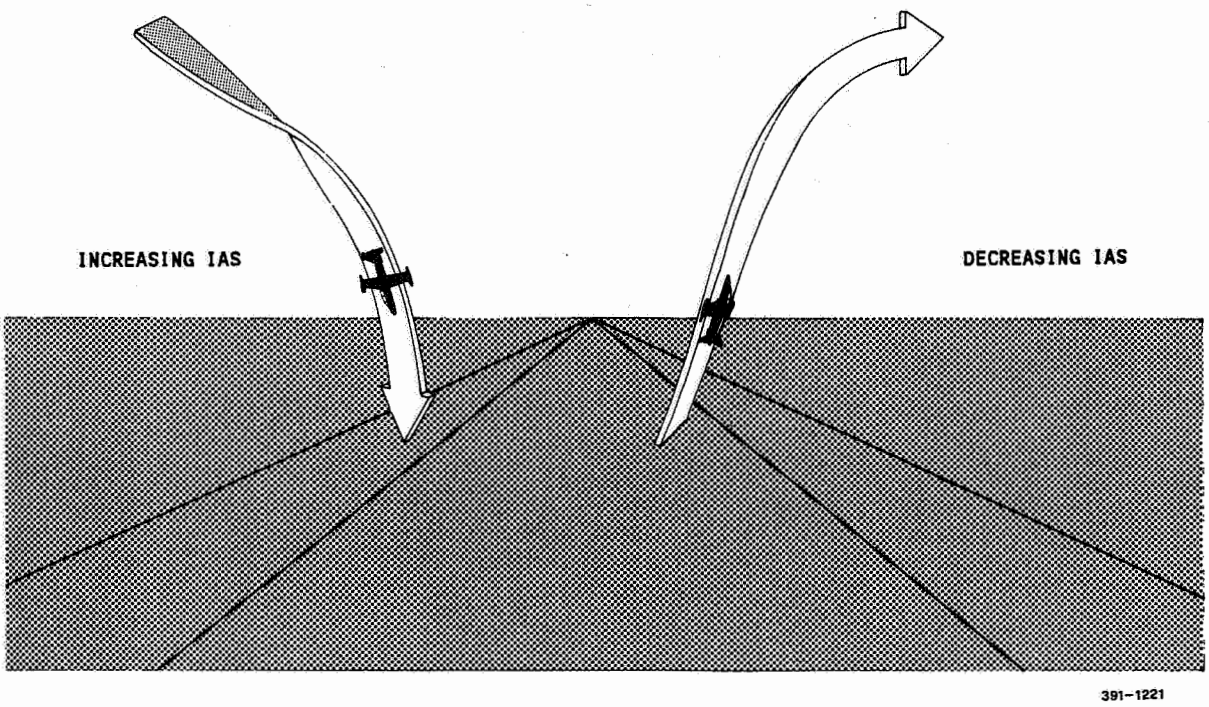


Figure 10-43. Unusual Attitudes

Bearing in mind the purpose of the exercise (i.e. to permit the pilot to resume aircraft control under very difficult conditions), the student pilot must honestly cooperate in the attainment of the disorientation that precedes the phase of recovery from unusual attitude; he should in fact close his eyes while the instructor brings the aircraft into the unusual attitude.

b. Visualization of the Unusual Attitude

As soon as the student pilot realizes that the aircraft is in an unusual attitude (sharply increasing speed or rapidly decreasing speed), he must first of all check whether the ADI and standby attitude indicator readings are in agreement (even if they are not perfectly coincident). If the readings of the two instruments are not consistent, check which ADI is OFF (flags) and consider only the indications of the operative instrument.
In the highly improbable case that both OFF flags are in view, assess pitch attitude basing on speed variations, on ALTITMETER READING CHANGES, on the vertical speed indicator, while roll attitude will be assessed on the gyrocompass and turn needle of the turn and bank indicator.

c. Corrective Actions

In any case, also when all instruments are operative and thus give reliable indications, the first instrument to look at to assess the pitch attitude (and its value) is the airspeed indicator.
Immediately afterwards, checking the ADI will give a confirmation and more detailed data. Since the ADI installed in the MB-339A is not ambiguous in inverted flight (the earth is always black and the sky white), and suffers from no precession, it will be comfortable and instinctive to roll the aircraft and resume roll control.
The recovery from unusual attitudes always and exclusively considers two possible conditions:

- Increasing speed
- Decreasing speed

This is made to automatize all immediate actions to take; at low altitude in fact every second gained during recovery could be the second that permits aircraft and crew to be saved.
The rapid assessment of the aircraft attitude simplifies the pilot's immediate actions aimed at timely recovery; these actions are in general:

- Instrument check actions
  * Attitude on the ADI (and standby artificial horizon)
  * Speed (increasing or decreasing)
  * Other instruments (altimeter, vertical speed indicator, turn and bank indicator)
- Piloting actions
  * On power setting
  * On flight controls (stick, rudder pedals, speedbrake)

(1) Unusual attitudes with increasing IAS (fig. 10-44 and 10-45). After assessing a nose down attitude (miniature aircraft in the dark area of the ADI earth sphere, airspeed indicator reading with increasing values), the recovery procedure will be as follows:

- Throttle at IDLE
- Level wings through the shortest travel
- With a bank angle smaller than 60°, start the pullup (AOA not greater than 0.8)
- With a wing bank angle of less than 45° lower the speedbrake if it is envisaged to exceed a speed of 250 KIAS (at high altitude 30 kt below the speed limit), and, with wings level, continue pulling up.
- Once straight and level flight conditions have been attained (miniature aircraft on the horizon line), restore the cruise parameters acting on power setting and retracting the speedbrake if out.
- Rapidly cross-check the instrument then resume the conditions preceding the entry in the unusual attitude

(2) Unusual attitudes with decreasing IAS (fig. 10-46 and 10-47).

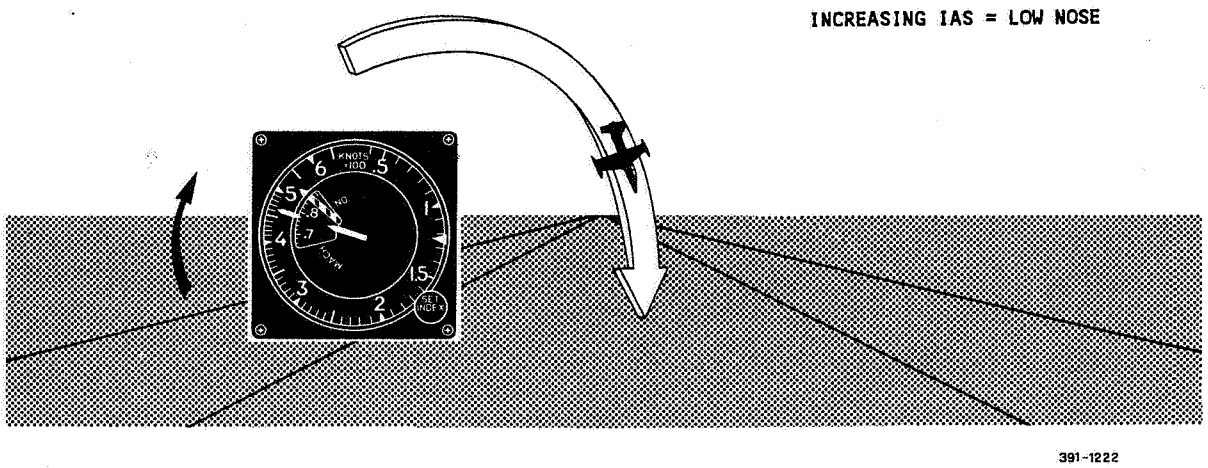
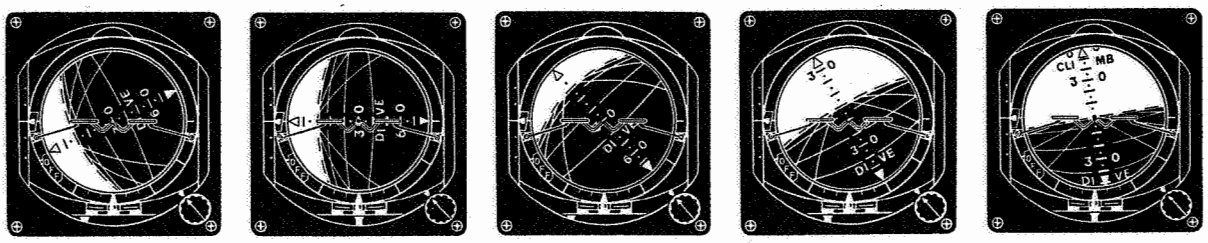
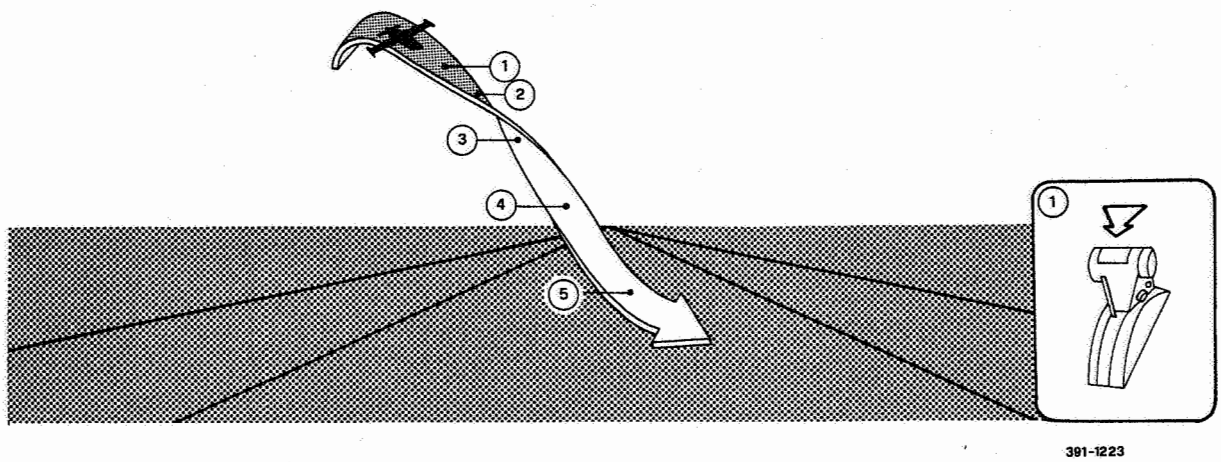


Figure 10-44 Indication of Unusual Attitude With Nose Low





1. THROTTLE AT IDLE
2. LEVEL OFF WINGS THROUGH THE NEAREST HORIZON
3. WITH A BANK ANGLE OF LESS THAN 60° START PULL UP
4. WITH A BANK ANGLE OF LESS THAN 45° SPEEDBRAKE OUT
5. LEVEL IN PITCH AND ROLL, SET RPM, IAS, SPEEDBRAKE AS REQUIRED

Figure 10-45. Recovery from Unusual Nose Low Attitude

After entering a nose-up attitude (miniature aircraft in the white area of the ADI earth sphere, airspeed indicator reading with decreasing values), the recovery procedure will be as follows:

- Throttle to full (to gradually attain 100% RPM), speedbrake UP (make sure)

- Bank the wings to 90° through the smaller angle and while retaining a slight back pressure on the stick (AOA not to exceed 0.8), check that the miniature aircraft on the ADI moves down toward the horizon line

- When the miniature aircraft crosses the horizon line (center dot of the miniature aircraft on the horizon line), with a speed of not less than 120 KIAS, level the wings and complete the pullup

- Carry out the straight and level flight corrections (miniature aircraft to coincide with the horizon line), then restore the cruise parameters

- Carry out a rapid cross-check, then return to the conditions preceding the entry in the unusual attitude

(3) Considerations

(a) From low nose

- Check that engine is at IDLE, and not at an intermediate position

- Take care to always level the wings through the shortest travel; if assessing the roll attitude on the ADI is confusing, more simply

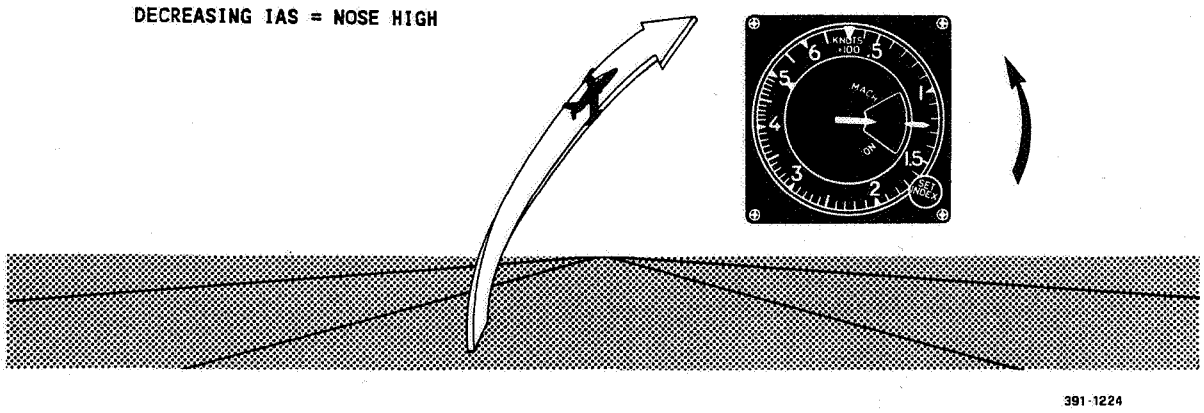


Figure 10-46. Indication of Unusual Nose High Attitude

refer to the turn needle, which points to the direction toward which the aircraft is banked.
Therefore to level the wings, move the stick in the direction opposite to the one indicated by the needle.

- When about to complete roll-out (bank angle smaller than 60°), start pullup with no delay to avoid an excessive loss of altitude.

- Extract the speedbrake with quite a lead in consideration of the marked dive attitude if it is estimated that the established speed will be exceeded. It is recommeded not to use the speedbrake at very high wing bank angles (higher than 60°) to avoid entering a steep spiral

- Pullup must be smooth to avoid a G-stall

- When the straight and level flight conditions are attained, suitably neutralize the controls with the required lead to avoid a possible entry in a nose-high unusual attitude; to this end, increase the frequency of the instrument cross-check

(b) From high nose:

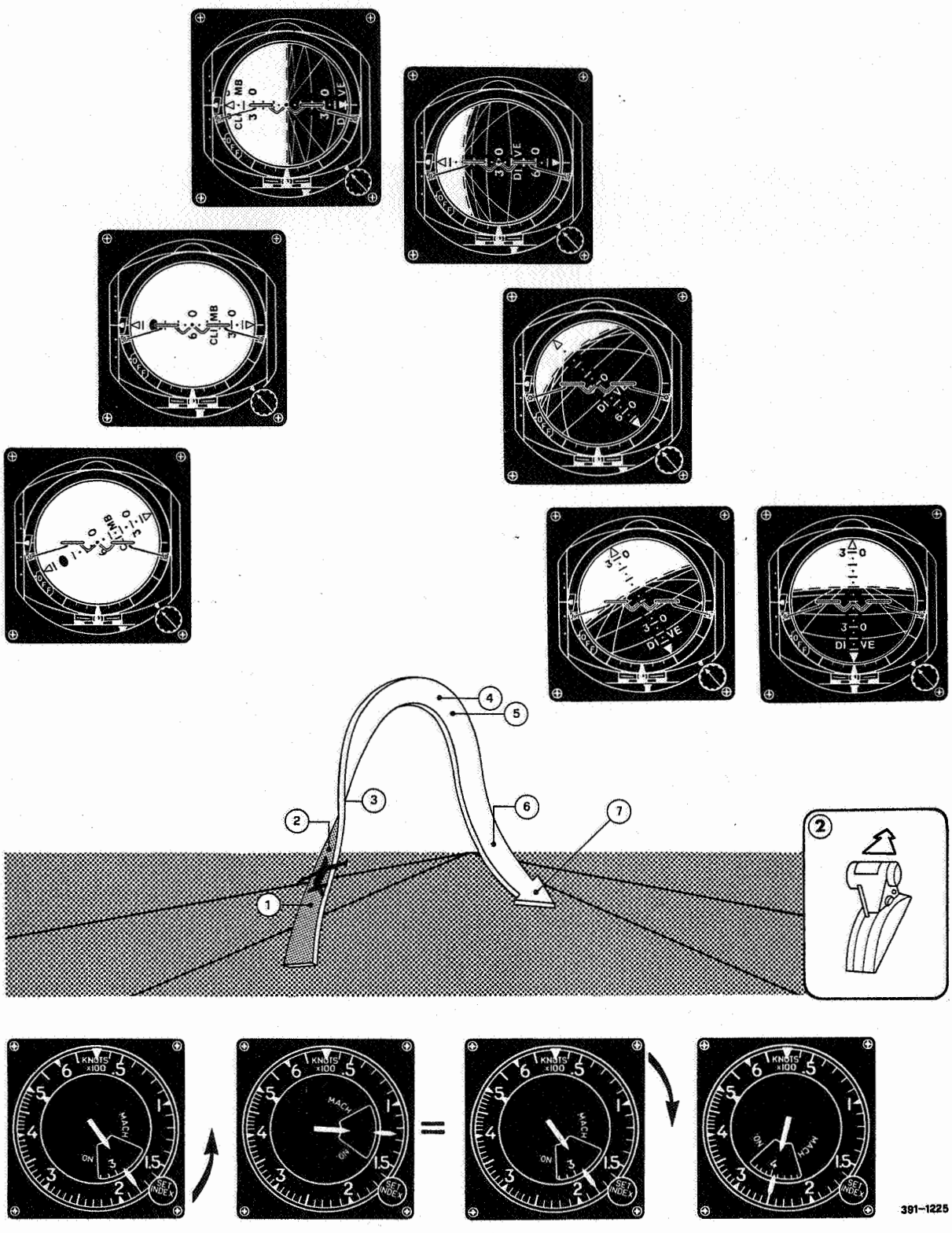
- Do not carry out sharp actions on the engine throttle in particular when attitudes are extreme and the IAS very low: this could lead to a compressor stall.

- During roll attitude changes do not excessively relax back pressure (negative g's), but keep the aircraft under positive acceleration.

- In presence of extreme attitude (shown on the ADI), it is permissible to exceed a wing bank angle of 90° and attain a max bank angle of as much as 100 to 110°; in this case, take care to bring the bank angle back to 90° when crossing the horizon

- If the horizon is crossed at speed lower than 120 KIAS, maintain wing bank angle unchanged and bring the aircraft below the horizon line; only when 120 KIAS are attained level the wings and start pullup.

- In particularly high nose situations it is not advisable to apply roll control. If, when evaluating the IAS (very low) and the attitude on the ADI (markedly nose-up), it is felt that the aircraft is approaching stall, it is necessary to act as follows, because, as well known, the ailerons are the first flight controls to loose effectiveness in such conditions and therefore their application might even complicate the recovery:



1. DECREASING IAS, AIRCRAFT IN SKY HALF OF ADI SPHERE
2. THROTTLE AT FULL
3. BANK WINGS 90°
4. CROSS HORIZON AND START ROLLING TO WINGS
5. INCREASING IAS, START APPLYING BACK PRESSURE ON STICK
6. RETURN TO CRUISE PARAMETERS
7. RETURN TO CONDITIONS PRECEEDING UNUSUAL ATTITUDE

Figure 10-47. Recovery from Unusual Nose High Attitude

- Throttle gradually advanced (100%) and speedbrake up (make sure)

- Stick neutral in roll and slightly forward the neutral point in pitch to lower the nose

- Once the straight and level flight conditions are attained, restore the cruise parameters

In the described situations, although the correct actions are taken, it is easy to enter in the opposite unusual attitude (low nose), which will be assessed and recovered by implementing the envisaged technique.

NOTE

- During recovery from unusual attitudes flown for training purposes, the maneuver is considered to be complete when the following conditions occur:
  - Level attitude
  - Constant altitude
  - IAS = Mach 0.5

  For the above reasons, it is therefore not necessary to resume the initial flight conditions
- Recovery from extreme unusual attitudes, both with high and low nose, entails a remarkable loss of altitude. In the real case, if at relatively low altitude, the pilot will have to establish (considering also the aircraft characteristics), a minimum safe altitude at which it is rather advisable to abandon the aircraft.

4. FLIGHT WITH INCOMPLETE INSTRUMENT PANEL

In the MB-339A aircraft, it is nearly impossible that the need to fly with an incomplete instrument panel arises in the real case, unless a nearly complete electrical failure occurs.

a. Simulated AHRS Failure

It is possible to simulate a total failure of the AHRS by disengaging the relevant circuit breaker (circuit breaker panel No. 1 on the left front console). The following instruments will remain operative: standby attitude indicator and turn needle, standby magnetic compass, HSI compass (provided the knob on the "AHRS" control panel is at "EMERG" - Front cockpit only), airspeed indicator, vertical speed indicator and altimeter.
Under these conditions, there are no difficulties in piloting the aircraft on the remaining instruments in IMC or with the blind flying hood in place

(1) Roll attitude. It can be maintained by referring to the standby attitude indicator bearing in mind that significant precession errors in roll will occur during the changes of IAS (check on the turn needle and, when aircraft has stabilized, on the compass as well).
Turns shall be of the timed type, and flown on the turn needle at rate 1,5 or 3 deg/sec.

(2) Pitch attitude. It can be maintained by referring to the standby attitude indicator bearing in mind that significant precession errors in pitch will occur during turns.

The combined use of the vertical speed indicator, altimeter and airspeed indicator will be made to monitor the attitude during turns.

b. Simulated Failure of the AHRS and the Standby Attitude Indicator

This failure, which is highly improbable in the real case, can be simulated by the instructor (pupil under the blind flying hood, and never in IMC), by pulling out the "AFT STBY ATT IND" circuit breaker (circuit breaker panel No. 2 on front right console) and "AHRS" circuit breaker (circuit breaker panel No. 1 on the left front console).
Instrument flying under this conditions requires a lot of attention and COOLNESS.
The most common error consists in fact of the rash chasing of the indications given by the "surviving" instruments.
It is conversely recommended to keep cool and reflect and to smoothly and "sparingly" use the controls to obtain, through subsequent attempts, smaller and smaller and increasingly precise adjustments of the desired parameters.
The maintainment of the parameters is facilitated by an adequate use of the trims.
It is underscored that important aeronautical achievements were reached by flying on the turn and bank indicator, airspeed indicator and altimeter only, and that the commercial aviation has guaranteed the continuity of air traffic also in IMC, for over ten years between WW I and WWII, relying only on these instruments.

(1) Roll attitude

- The indications of the turn and bank indicator replace the bank indications previously supplied by the artificial horizon and ADI.

- Maintainement of the flight line will be guaranteed by the following indications: TURN NEEDLE AND BALL AT CENTER, FIXED READING on GYROCOMPASS (OR MAGNETIC COMPASS).

- Turning flight will be accomplished by avoiding exceeding the bank angles of rate 1 or rate 1/2. In this case too, the ball of the turn and bank indicator will necessarily have to be kept at center.
During roll-out on the magnetic compass, the lead or delay technique will have to be implemented, as is typical of this instrument.

(2) Pitch attitude (fig. 10-48)

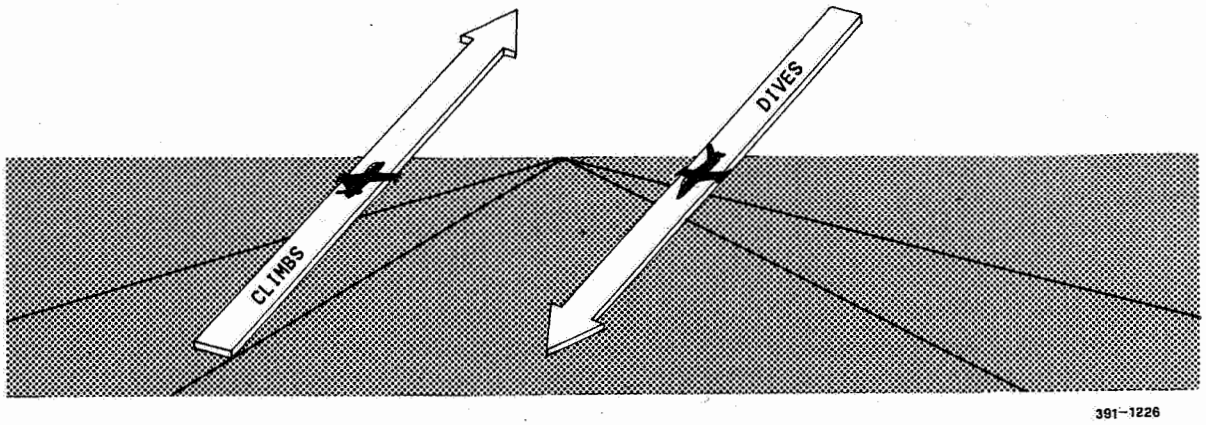
- The combined use of the vertical speed indicator, altimeter and airspeed indicator replaces the pitch up - pitch down indications provided by the ADI.

- As far as the greater sensitivity of an instrument with respect to the other and its more immediate response are concerned, it is recommended to monitor the vertical speed indicator first, in particular when trends are to be evaluated.

- Experience and skill will permit the pilot to correctly evaluate the different instrument readings and to properly consider their errors and lags.

c. Recovery from Unusual Attitudes with Incomplete Instrument Panel

The probability of actual concurrent failure of the ADI and standby attitude indicator is so remote to be practically nil.
It is however advisable that the pilot knows how to recover from unusual attitudes with incomplete instrument panel.



CLIMB	DIVE
- ALTIMETER: ALTITUDE INCREASES	- ALTIMETER: ALTITUDE DECREASES
- AIRSPEED INDICATOR: IAS DECREASES	- AIRSPEED INDICATOR: IAS INCREASES
- VERTICAL VELOCITY INDICATOR: POSITIVE VALUES OF VERTICAL SPEED	- VERTICAL VELOCITY INDICATOR: NEGATIVE VALUES OF VERTICAL SPEED

Figure 10-48. Indications of Climb and Dive

In the MB-339A aircraft, some electrical failures entail the loss of both the ADI and turn and bank indicator data. In this case, if the standby attitude indicator has failed too, recovery with incomplete instrument panel is not feasible.
It is pointed out that the standby attitude indicator will be available until the batteries are fully discharged; subsequently the artificial horizon will provide reliable indications for four minutes after the OFF flag comes in view, then the indications will become unreliable.
It is underlined that in the real case it is very improbable that the turn needle is operative with both artificial horizons out of work, but if this should occur, it is essential that the pilot knows the correct procedure to recover from unusual attitudes with incomplete instrument panel, that is without the gyroscopic attitude indicating instruments. In this case, the following actions are to be taken:

- Assess the pitch attitude (whether nose-up or nose-down) on the airspeed indicator, altimeter and vertical velocity indicator; immediately act on power setting and, if required, on the speedbrake (100% RPM and speedbrake up, or IDLE and speedbrake down).

- Then assess roll attitude (use the turn and bank indicator) and move the stick to the side to displace (nose high) or center (nose low) the needle of the turn and bank indicator; in any case, avoid exceeding the turn values shown on the turn and bank indicator.

- Bring the aircraft back to the flight line attitude from the nose-up or nose-down attitude acting on pitch control.
The trend to reverse the indications shown by the airspeed indicator, altimeter and vertical speed indicator (values from decrease to increase or viceversa) will witness that the aircraft is crossing the line of flight and the pilot has resumed a partial control of the aircraft.

- Once the aircraft has stabilized on the line of flight, maintain the parameters with a suitable monitoring of the attitudes.

- Roll attitude

Turn needle and ball at center, constant reading of magnetic compass

- Pitch attitude

Altimeter on constant reading, vertical velocity indicator reading zero, airspeed indicator on constant value.

NOTE

In case of recovery from unusual attitudes with incomplete instrument panel and in IMC, the inverted flight condition and the condition with extreme nose-up attitude, require special consideration. A real possibility to incur in an excessive loss of altitude during recovery exists for the first instance, whilst the concrete danger to loose aircraft control as a result of a stall exists in the second one. It is therefore opportune that in IMC and with aircraft out of control, the pilots considers the possibility of ejecting.
To this end, the minimum altitude at which recovery attempts must be discontinued to eject must be established beforehand basing on the aircraft performance and ejection system characteristics.

5. RADIO AIDED INSTRUMENT FLYING

The radio aided instrument flying requires a thorough knowledge of and familiarity with the airborne instrument and navigation equipments, as well as with the corresponding ground radio aids.
It has therefore been considered advisable to prepare a special publication to cover this subject, which is entitled "Instrument Flying and Navigation Manual" PI AD-03-39A".
Some elements of radio-navigation are covered by Chap. XI, Para 3 hereafter.

PART THREE - CHAPTER XI

BASIC NAVIGATION

TABLE OF CONTENTS

Title	Page
Introduction	11-1
Dead Reckoning Navigation	11-2
Very Low Altitude Navigation	11-18
Study and Preparation of Very Low Altitude Training Missions	11-27
Performance of Very Low Altitude Training Missions	11-40
Very Low Altitude Aerotactical Navigation Rulers	11-44
Radio Aided Navigation	11-47

1. INTRODUCTION

- The systems for radio aided navigation and dead reckoning navigation and the instruments for instrument flying and navigation installed in the MB-339A aircraft are quite sophisticate and require that special procedures be implemented for them to be correctly used.
Publication PI AD-03-39A "Instrument Flying and Navigation Manual" was prepared with this aim.
Familiarity with and frequent reading of the above manual are essential to conduct navigation and instrument flying in the MB-339A aircraft.

- This Chapter XI provides only brief and generic information as to the preparation of dead reckoning (D.R.) navigation at low and medium altitude, as well as some useful data for planning IFR flights to be flown by relying on radio aids both in IMC and VMC.

- There is no activity in the air which does not include a navigation leg. To fly from one point to another along a pre-set course it is in fact necessary to make use of the navigation notions learnt during the theoretical training phase and above all to conform to the existing air traffic and safety rules.
Depending upon the operational requirements, the weather conditions, and the altitude of flight, navigation can be:

- Visual dead reckoning, at low and medium altitude
- At very low altitude
- Radio-aided (at low, medium and high altitude)
- Dead-reckoning, at all altitudes.

NOTE

The following intervals of altitudes/levels have been established to provide a guidance for training and operational purposes; they have no absolute value:
Very low altitude up to 1000 ft AGL (*)
Low altitude from 1500 ft AGL to Flight Level 95 (**)
Medium Altitude from flight level 100 to flight level 195
High altitude from flight level 200 to flight level 350 (***)
Very high altitude above FL 350 (370 and above) (***)

* For flying schools: up to 1500 ft AGL
** For flying schools from 2500 ft MSL to FL 95
*** In IFR only if outside of airspace assigned to military flights

The radio navigation instruments and systems installed in the MB-339A are complicated but precise, and permit high accuracy navigation.
One pilot can cope with the workload involved by them and aircraft piloting.
It is therefore necessary that the pilot be familiar with the use of the navigation aids, and be able also to fly without them; this can be done by simulating their failure or unavailability.
The military pilot must also be capable of flying in dead reckoning mode only.

2. DEAD RECKONING NAVIGATION

a. General

Dead reckoning navigaton is the navigation flown basing on the observation of the overflown terrain integrated with the estimated data of true heading and groundspeed (from which the estimated position is obtained), derived from:

- Weather data for forecast winds
- Observations made during the previous navigation leg
- Gyrocompass and clock reading, IAS reading
- TAS calculation (from IAS, altitude and temperature)

WARNING

Dead reckoning navigation is permitted in VFR only.

Dead reckoning (DR) consists of calculating the heading, track, ground speed and position of an aircraft in flight basing on the available forecast of wind speed, and on TAS.
The altitudes at which DR flights can be flown are:

LOW ALTITUDE : from 2500 ft to FL 95

MEDIUM ALTITUDE: from FL 100 to FL 195

Before flight, a few essential operations must be accomplished.

b. Preparation of Dead Reckoning Navigation

(1) Choice of the map. Choose the chart that is most suited to the altitude selected for flight, and to the area to be overflown. Both this whole area and the areas adjacent to the planned course must be depicted in the map.
For VFR navigation a 1:500 000 chart is recommended (especially if flying at approx. 10 000 ft), as it adequately delineates the landmarks that can be used as navigation checkpoints.

(2) Choice of the track (fig. 11-1). The track chosen on the chart should be a straight or broken line going from the departure point to destination.
When choosing a track, consideration should be given to the following items:

- General features of the terrain, its appearance and presence of natural or artificial obstacles

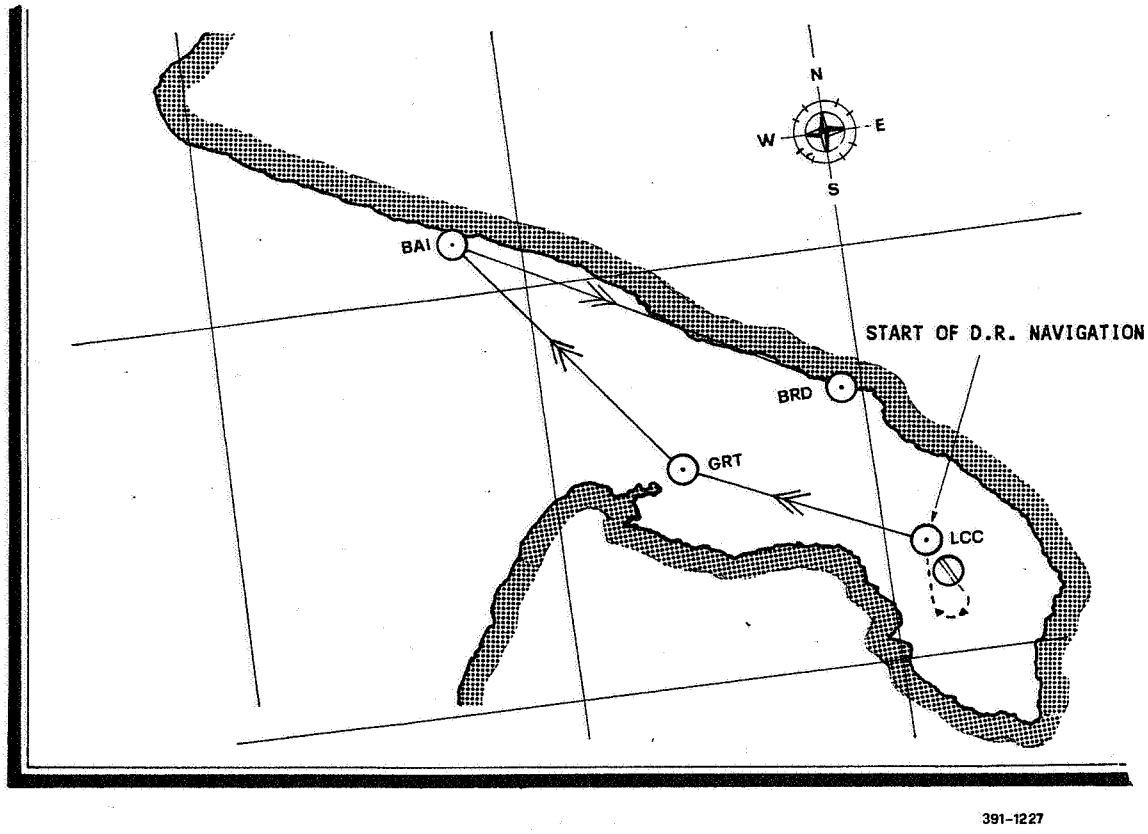


Figure 11-1. Selection of Track

- Availability of alternate airports or airfields that can be used in an emergency

- Air space restrictions (prohibited areas, danger areas, controlled areas, notams)

- Different elements connected with the safety of flight

- General weather conditions

To mark the track on the chart, refer to the very low altitude navigation symbology.

(3) Checkpoints. Select checkpoints that meet the requirements for uniqueness (checkpoints that cannot be confused), contrast (shape and color), distance (time interval between two chosen checkpoints), prominence (with respect to the general relief characteristics of the terrain). Bear in mind that these checkpoints will have to be changed as a function of the flight altitude, overflown landscape, season, etc.
Under normal conditions, these checkpoints will be identified by locating them first on the map and then on the ground.

NOTE

Navigation will begin at a point close to the airport which is clearly recognizable and suited to be overflown with already stabilized parameters irrespective of the runway in use.

(4) Radio aids (fig. 11-2). During planning, give consideration to the radio aids that can be found along the course, and to those which could be useful in case of diversion to an alternate airport.

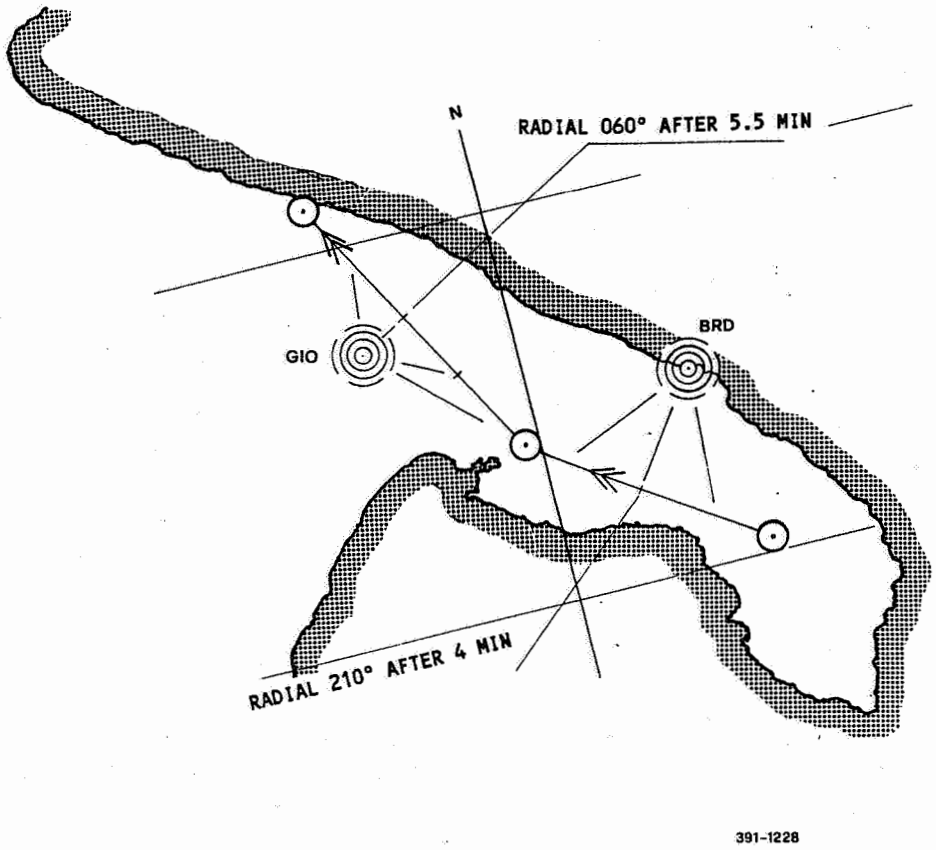


Figure 11-2. Selection of Radio Aids

After selecting the stations, write down their characteristics (frequency, range, types of wave, operation time), and, if necessary, mark some position lines characteristic of each radio station on the chart.
If navigation envisages that a different airbase is overflown or landed on, it is necessary that the procedures in use over that base and the frequencies available for normal communications with all regional and local air traffic control activities be known.

(5) Essential publications for flight planning and navigation. These documents must be examined to obtain precise and updated information on the course and the alternate airports.

c. Flight Log

This flight log includes all data concerning the flight, and its aim is to reduce the pilot's mental workload in flight. The flight data list help remove the possibility that something important be forgotten and must be prepared so as to be useful also for a pilot called to replace his colleague even as late as a few minutes before take-off.
When compiling the flight log, the following items must be considered:

(1) Data drawn from chart

- TRUE HEADING
- Magnetic variation
- Magnetic heading
- Checkpoints
- Distance

- Safe altitude (it is obtained by finding the height of the highest obstacle in a strip of 10 NM on both sides of the route, rounding off the value to the next 100 ft and adding 2000 ft to the resultant value).

(2) Data from flight information publications

- Available radio aids, frequencies, hours of operations, location, etc.

- Alternate airports, radio aids and various information

- Airport departure procedure

(3) Data from briefing

- Weather information and forecast on selected course

- Altitudes. For the selection of the flight level above the safe altitude calculated using the chart, the following data are to be considered:

* Meteo forecast information (icing conditions, clouds, wind at altitude, thunderstorms, etc).

* Possible restrictions enforced by NOTAMS

* Semicircular levels as a function of magnetic heading (fig. 11-3)

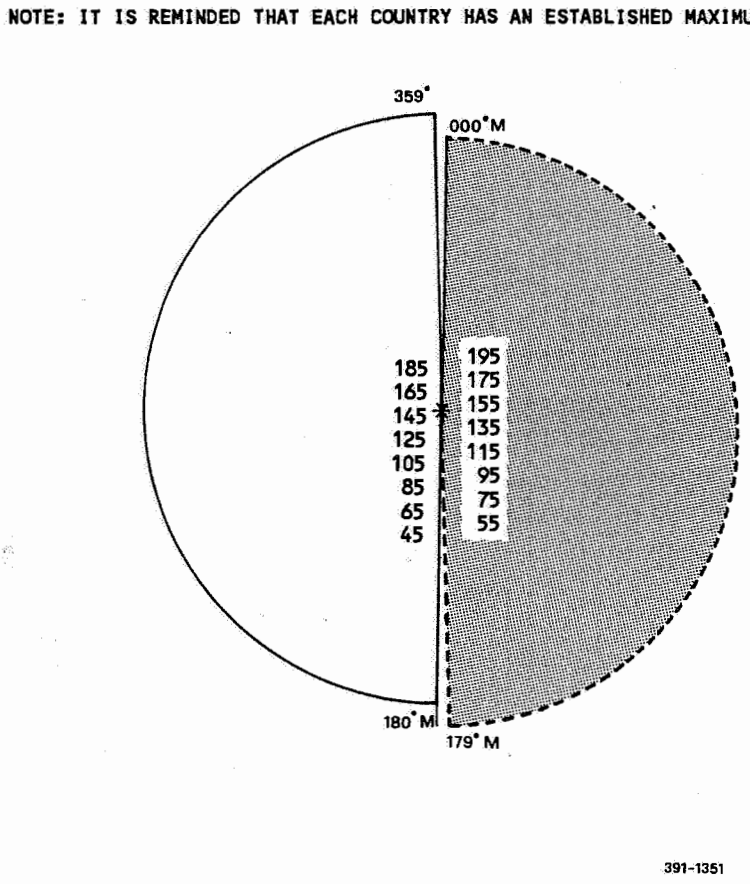


Figure 11-3. Semicircular FL's Applicable to VFR

(4) Data from calculation

- True airspeed. In the MB-339A aircraft, maintain a IAS corresponding to Mach 0.5 (INM 0.5) INM = INDICATED MACH NUMBER

- True heading

- Drift and drift correction

- Magnetic heading

- ETE (estimated time enroute)

- Estimated fuel consumption (partial, total, remaining) considering diversion to the alternate airport.

NOTE

Normally, the planning of a training mission is made the day before the flight, therefore, wind being unknown, the GS cannot be assessed. The course will however be planned by considering a IAS of Mach 0.5. The following day, just before flight, the wind will become known and the planned course, GS, total and partial flight times and finally fuel consumption will be modified accordingly.

d. Short Notes on the Navigation Documents

Continuously updated information and documents are made available to the pilot who must examine them before any flight. To confirm that the documents have been examined, the pilot must take and sign a copy of the following documents:

(1) En-route meteorological sheet (fig. 11-4). The pilot must inform the weather station in due time for its preparation. This period of time varies depending upon the meteo service existing at the base. Before collecting this sheet from the weather station, the pilot is requested to examine it and ask for any necessary clarification.
The weather information is not a clearance. The decision and responsibility as to whether carry out the flight remain with the pilot.

(2) Flight plan. The flight plan must be handed to the responsible ARO at least 15 minutes before the estimated time of departure. The ARO will advise all other necessary information on air traffic, landing possibility, temporary air space restrictions, etc.

- The flight plan will include the meteo sheet registr number to confirm that the weather data have been examined.

- Figure 11-5 shows the flight plan prepared for the flight on the route: LECCE-GROTTAGLIE-BARI-BRINDISI in Southern Italy.

NOTE

The pilot must carry with him copies of these documents, and note any difference observed between the forecast and the actual weather conditions. The pilot will hand the documents to the ARO of the destination airport when he closes his flight plan.

e. Performance of Dead Reckoning Navigation

Throughout the flight, the actual flight conduct should conform the planning accomplished.

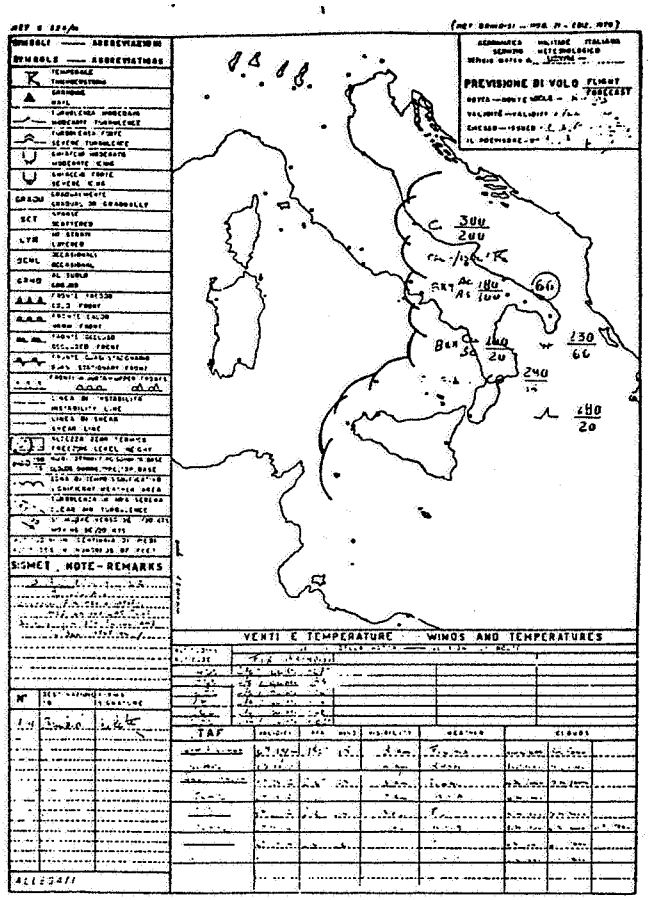


Figure 11-4. En-route Meteorological Sheet

Aircraft piloting takes only a part of pilot's attention and time: pilot's attention must in fact be shared among piloting, reading of the chart and identification of the checkpoints on the ground.

(1) Interception of initial course (fig. 11-6). On turning out of the traffic pattern, the pilot will head to the departure point; after overflying it, he points the aircraft to the envisaged heading and starts the stopwatch.

(2) Checkpoints (fig. 11-7). If navigation has been accurately and precisely planned it will be possible to locate all enroute checkpoints in advance and easily follow the actual flight path.
In case a deviation from the planned course is noted, it is necessary to assess the amount of deviation and decide whether to return on the planned course (this is the case of 'obliged' routes because of topography or air traffic constraints), or to fly a convergent course to intercept the subsequent checkpoint.

(3) Getting back on course. Correction to get back on course are performed according to three techniques: visual return on the CHECKPOINT, return according to the "2 α method", return on course with by use of the drift lines.

(a) Visual return on the checkpoint. This is the most widely adopted method and consists of bringing the aircraft on a checkpoint by use of the visual references. Once back on course, normal navigation can be resumed but attention should be given to the cause of the out of track displacement (wind, piloting error, error of the HSI, etc.)

PIANO DI VOLO - *FLIGHT PLAN*

INDICATORI DI PRIORITA' *Priority indicator*	INDICATORI DEI DESTINATARI *Addressee (s) indicator (s)*
ORA PRESENTAZIONE *Filing time*	INDICATORE D'ORIGINE *Originator indicator*

IDENTIFICAZIONE ESATTA DEI DESTINATARI E/O DEL MITTENTE
Specific identification of addressee (s) and/or originator

1 DESCRIZIONE *Description*	6 IDENTIFICAZIONE AEROMOBILE *Aircraft identification*	8 REGOLE DI VOLO E CARATTERE SPECIALE DEL VOLO *Flight rules and status*
(FPL	— LION 82	— VFR

9 NUMERO E TIPO AEROMOBILI *Number and type of aircraft*	10 EQUIPAGGIAMENTO - *Equipment* COM / NAV / SSE
— N° 1 MC 32	— B / B / F

13 AEROPORTO DI PARTENZA *Aerodrome of departure*	ORA *Time*	CONFINI FIR E ORE STIMATE *Fir boundaries and estimated times*
— LIBN	09.30	→ N.M.

15 VELOCITA' *Speed*	LIVELLO *Level*	ROTTA *Route*
—	F185	→ LCC GRT BAI BRD

17 AEROPORTO DI DESTINAZIONE *Aerodrome of destination*	ORA *Time*	AEROPORTI ALTERNATI *Alternate aerodromes*
— LIBR	10.10	→ LIBV

18 ALTRE INFORMAZIONI *Other information*

—

19 INFORMAZIONI SUPPLEMENTARI - *Supplementary information*
AUTONOMIA - *Endurance* | PERSONE A BORDO - *Persons on board* | EQUIPAGGIAMENTO DI EMERGENZA E SOPRAVVIVENZA - *Emergency & survival equipment*

— FUEL/ → POB → RDO/121.5 → 243 → 500 → 8364

EQUIPAGGIAMENTO *Equipment*						CINTURE DI SALVATAGGIO *Life Jackets*	FREQUENZA *Frequency*
POLARE *Polar* →	PER DESERTO *Desert* →	MARITTIMO *Maritime* →	PER GIUNGLA *Jungle* →	CINTURE *Jackets* →	LAMPADE *Light* →	FLUORESCINA *Fluorescein* →	

CANOTTI *Dinghies*	COLORE *Colour*	NUMERO *Number*	CAPACITÀ TOTALE *Total capacity*	ALTRO EQUIPAGGIAMENTO *Other equipment*
CANOTTI *Dinghies* → COPERTA *Cover*				→ RMK/

	NOME DEL COMANDANTE *Name of Pilot-in-command*	FIRMA DEL COMANDANTE O DEL SUO RAPPRESENTANTE *Signature of Pilot-in-command or designated representative*
INSTR. RATING	CAP. BROWN	

1st Police State

Figure 11-5. ICAO Flight Plan

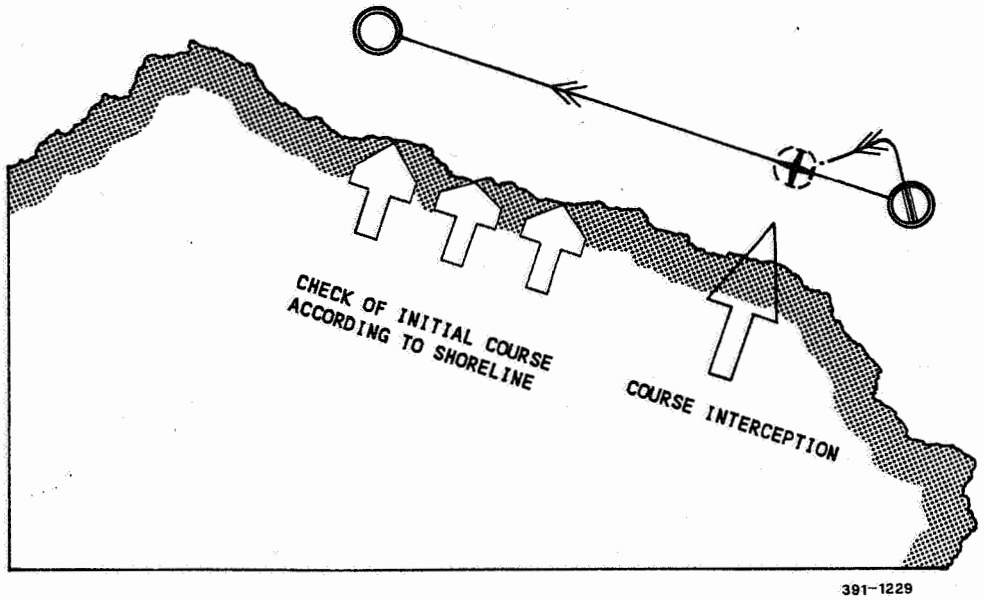


Figure 11-6. Interception of Initial Course

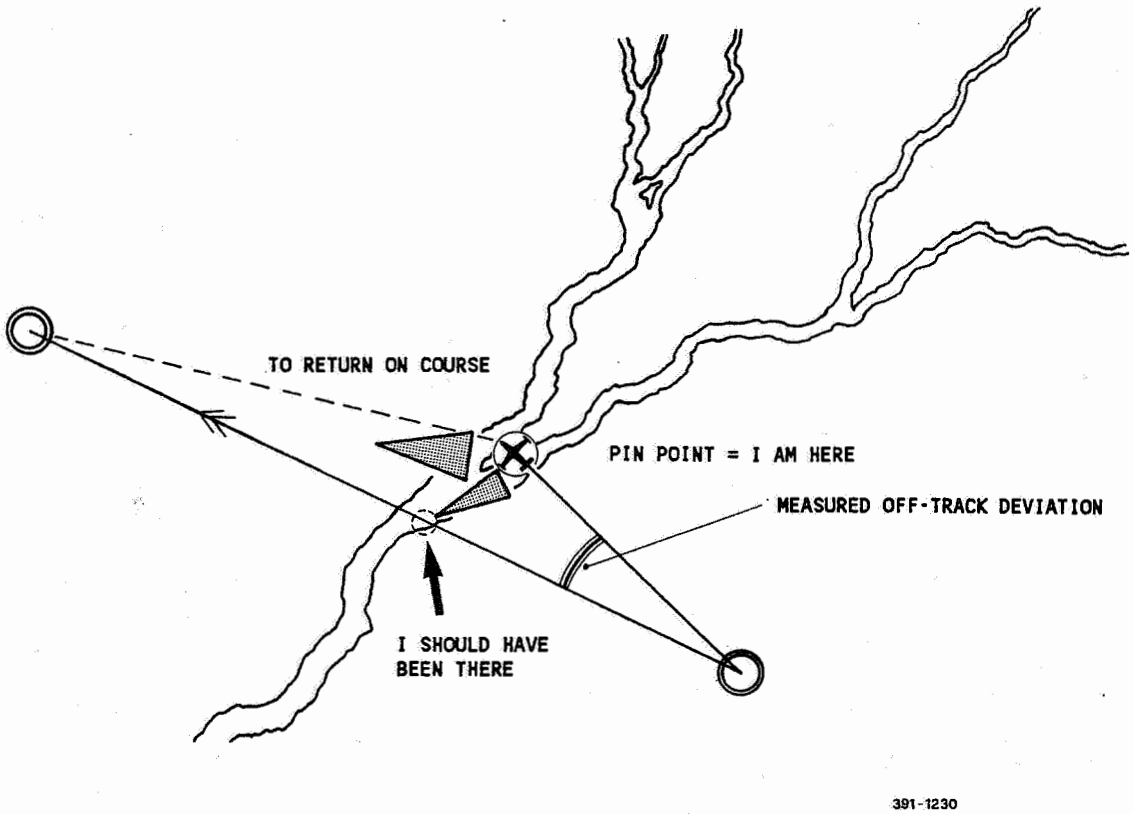


Figure 11-7. Check points

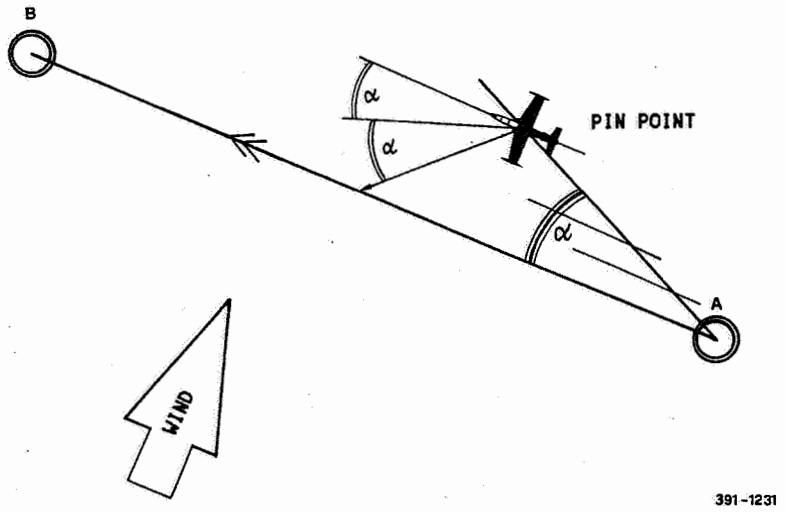


Figure 11-8. Return on Course by Method 2α

(b) Return on course by method "2 α" (fig. 11-8). Once the out of track position of the aircraft has been ascertained over a positively identified point, the angle between the actual path flown by the aircraft and the planned course should be approximatively calculated. A very shallow turn of twice the thus calculated angle will then be flown to close on the desired course.
The new heading will be maintained for a time equal to the time elapsed from the last check on course. After this interval resume the planned heading plus drift correction.

(c) Return on course by drift lines (fig. 11-9). The purpose of this method is not to return on the planned course but to return on a planned checkpoint. Once the aircraft out of track position over a positively identified point is ascertained, calculate the angle between the actual aircraft flight path and the planned route with sufficient accuracy. Adding this angle (α) to the angle (β) necessary to get back on course, and entering a turn in the direction opposite to out of track displacement as wide and the angle resulting from the above sum, permit return on course to be obtained.

NOTE

In any triangle, the sum of two angles adjacent to the same side is equal to the external far angle.

To evaluate β, remember the ONE TO SIXTY rule (an arc of 1NM is subtended to an angle of 1° at a distance of 60 NM).

(4) Heading. The heading computed during planning is to be scrupulously maintained on the HSI and periodically checked on the magnetic compass.

(5) Checkpoints and turning point (fig. 11-10). These are the points joining the different navigation legs. In proximity of each checkpoint, carry out the following actions:

- Check point overflying time (stopwatch: set to zero and start when overhead)

- Store new heading by means of the "SET HDG" knob on the "AHRS" control panel

- Consider safe altitude on the new leg

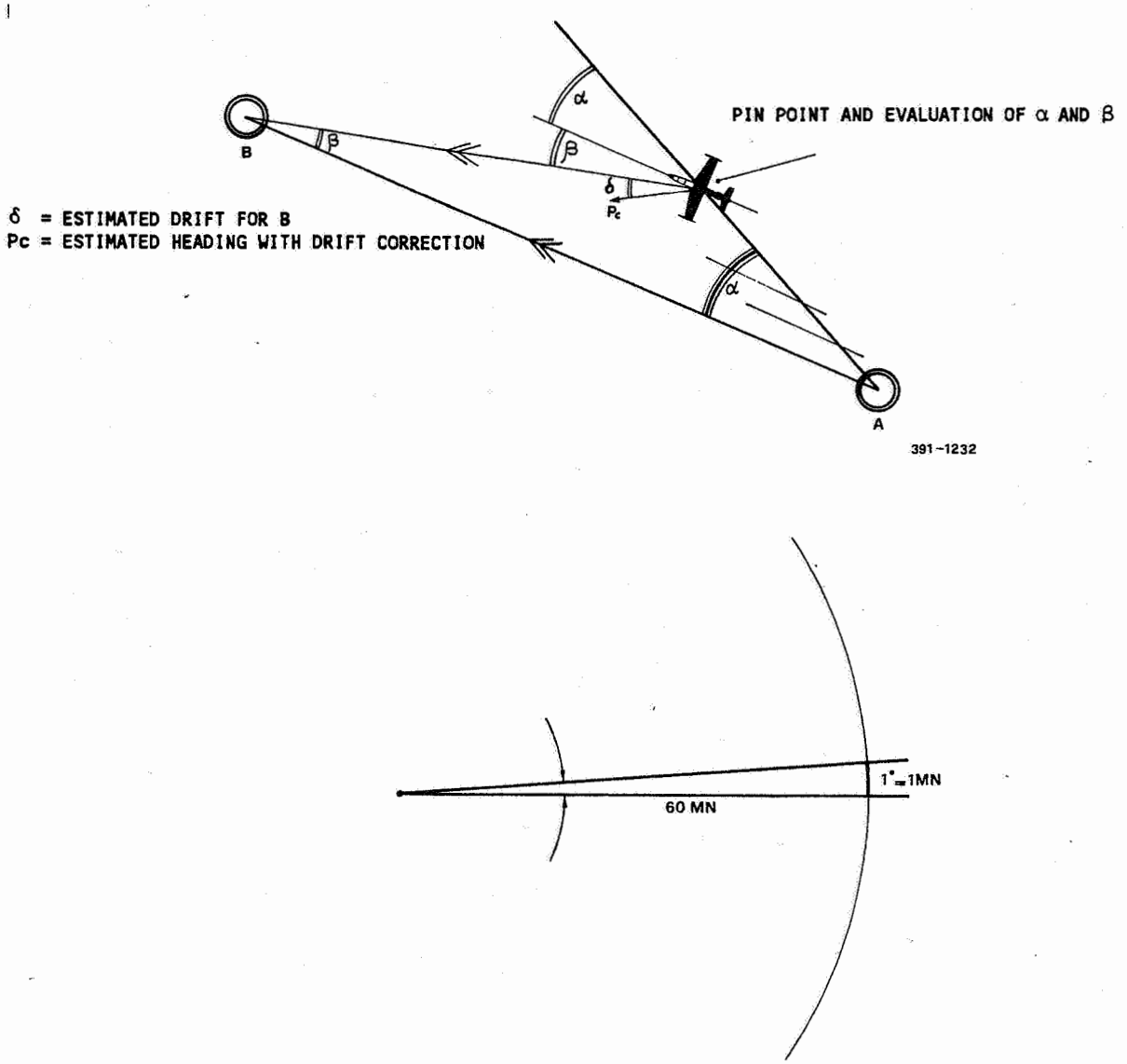


Figure 11-9. Return on Course by Drift Line Method

- Consider estimated time to the next checkpoint
- Check fuel and fuel remaining on next estimated checkpoint
- Consider the estimated time to next checkpoint

(6) Time. If the different checkpoints are overflown ahead of or behind the planned schedule, power setting must be changed to remove the noted error.

(7) Radio aids. When radio aids are available enroute, they will be exploited to check the correct ground path of the aircraft.

(8) Radio communications. All radio communications must be as clear as possible and conform to the prescribed standard.
Example of a radio communication when leaving the frequency of the tower of the departure airport (in VFR too): - after leaving the traffic pattern of the departure airport, contact the Flight Information Center (FIC) and inform: DEPARTURE AIRPORT AND TIME, POSITION, CONDITIONS AND FLIGHT LEVEL, ESTIMATED TIME TO NEXT CHECKPOINT, OR FIR BOUNDARY ETA, OR DESTINATION AIRPORT ETA: (ex. Lion 82, departed from Jumbo at zero five presently overhead Silverlake - climbing to flight level 185, estimates Greenhill at two five).

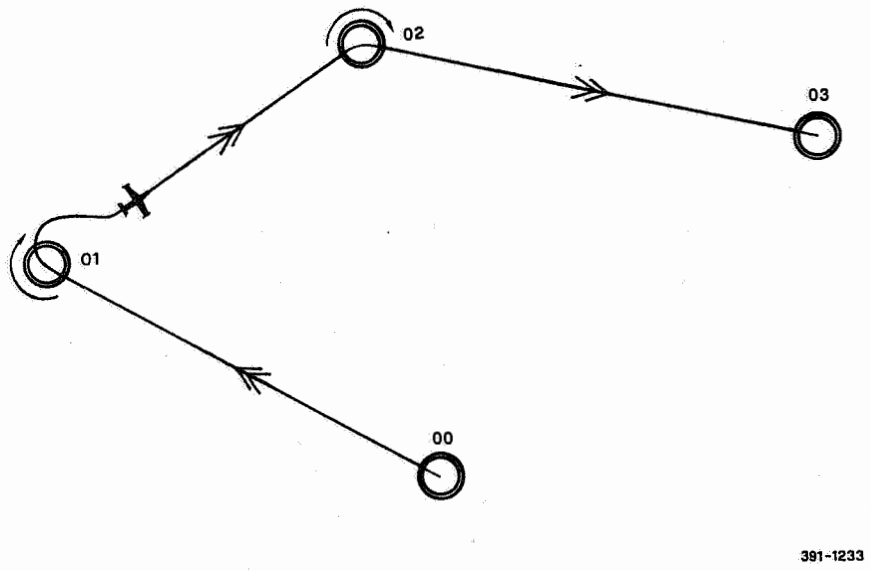


Figure 11-10. Turning Points

- When about to enter another FIR, the pilot must inform the FIC of: time at which boundary is crossed, level and change to the frequency of the other center.
(ex. Charlietown information, this is Lion eight two leaving your FIR at three-seven, flight level one eight five, changing with Blossom information. Out).

The following information will be advised to the FIC of the FIR in which the aircraft enters: position and FIR boundary crossing time, flight conditions, flight level and estimated time on next checkpoint.
Ex. Blossom information this is Lion 82 entering your FIR at four zero, VMC, flight level one eight five, estimates Winchester at four-nine, over.
If aerodrome traffic zones or controlled airspace are to be entered during navigation, clearance to do so must be requested to the tower or to the concerned air traffic control activity informing of actual flight level. In these areas, it is compulsory that the pilot maintains radio listening during transit on the frequency on which contact was originally established.

- When the destination airport is in sight or when about to enter its aerodrome traffic zone, it is necessary to contact the FIC and inform them that their frequency is being left and contact established with the airport tower.
(ex. Charlietown information, this is Lion 82: entering Jumbo area. Leaving your frequency. Out).
Then, the Tower will be contacted, informed of position and requested of instructions to enter the traffic pattern and land.

(9) Destination airport. After obtaining the required instructions, enter the pattern by following the standard procedure; it should be borne in mind that the elevation of the destination airport is probably different from the elevation of the departure airport, therefore, it is necessary to comply with the local pattern altitude requirements

- After landing, taxi adhering to the instructions received from the tower or following the FOLLOW ME truck; in case of doubts as to the direction to take, halt.

(10) Aerodrome reporting office (fig. 11-11). If the flight is concluded, the aircraft must be parked making sure that it is taken over by ground personnel, and the pilot must report to the ARO, which is identified by a black C on a yellow background in all airports.
Here the flight plan is closed and the flight meteorological sheet handed with the necessary notes.

NOTE

If landing occurs on an airport which is not the seat of an ATS, the pilot must close his flight plan either by calling the responsible ATS on the radio just before landing or by contacting the responsible activity through the available ground means (phone, etc.).

The above is essential to prevent the Search and Rescue Service from being alerted.

f. Safety

(1) Map reading. Map reading is a particularly important action for the pilot-navigator who has available just a few instants to look at the chart, as he must above all keep his eyes out. He therefore has to obtain the largest possible number of information from short glances at the chart.
The accurately folded charts (like an accordion) (fig. 11-20, sheet 1), which are clearly marked with the course, checkpoints, distance between checkpoints (decreasing distances marked on the left of the course), and flight times (increasing times marked on the right of the course), are very useful to quickly fix the aircraft position.

(2) 5° convergent - divergent lines (fig. 11-20, sheet 2). Map reading, in visual navigation, is made far easier if in addition to the thick line indicating the course between one WPT and the following, a set of thin lines that diverge of 5°, 10° and 15° is traced on both sides of the course.

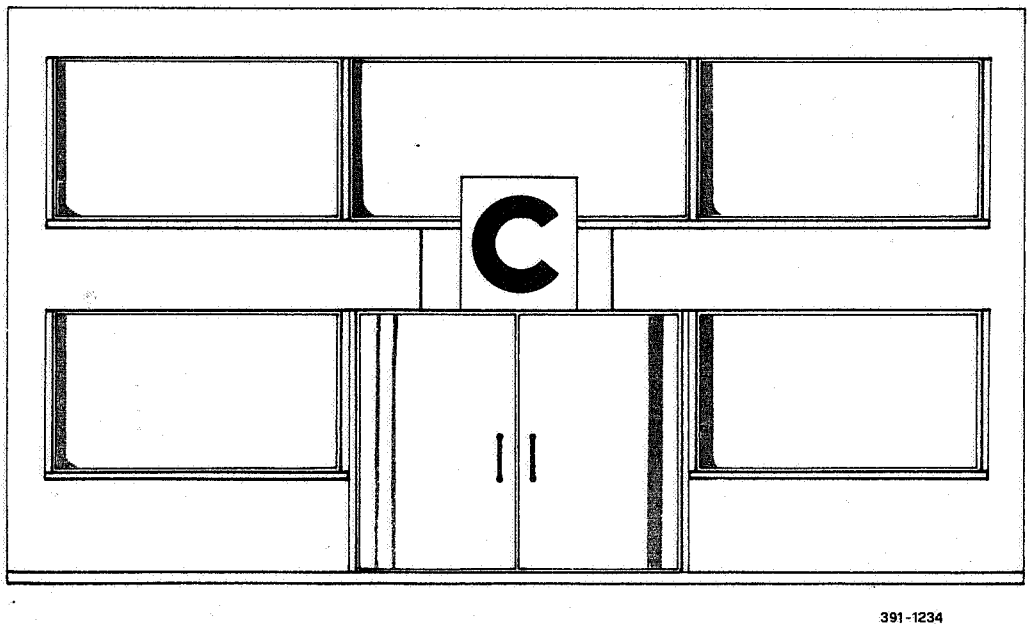


Figure 11-11. Aerodrome Reporting Office (ARO)

These lines will be expedient in determining the amount of the out of track deviation as well as of the correction needed to get back on course.

(3) Orientation (fig. 11-12). For an easy orientation during navigation, the course on the chart should be kept aligned in the direction of the course on ground.
As already pointed out, it will be necessary to check the terrain landmarks slightly ahead of time. If disorientation occurs, it should be remembered that, if no gross heading errors have been made and displacement is due to drift or other causes, the error usually does not exceed an amount equal to 10% of the travelled distance. It is therefore possible to estimate the aircraft position by tracing a circle with a 1 NM radius for every 5 minutes of flight time since the last position fix: the aircraft should be within such an area. Recognition of the overflown area will be obtained by observing the terrain first and then the chart.

- If disorientation persists, it should be remembered that when altitude increases, the visual range also augments, and a greater number of landmarks is therefore visible and identifiable.

- If also this procedure should be ineffective, check and use the airborne radio-communication equipment to determine the position with respect to a radio aid or request that bearing be determined to the ground station thought to be the nearest one, or, in extreme cases, request radar assistance.

- If for a reason whatever, radio contacts cannot be established and disorientation persists, carry out the envisaged emergency procedures by placing the IFF to Mode 3A code 77 (fig. 11-13).

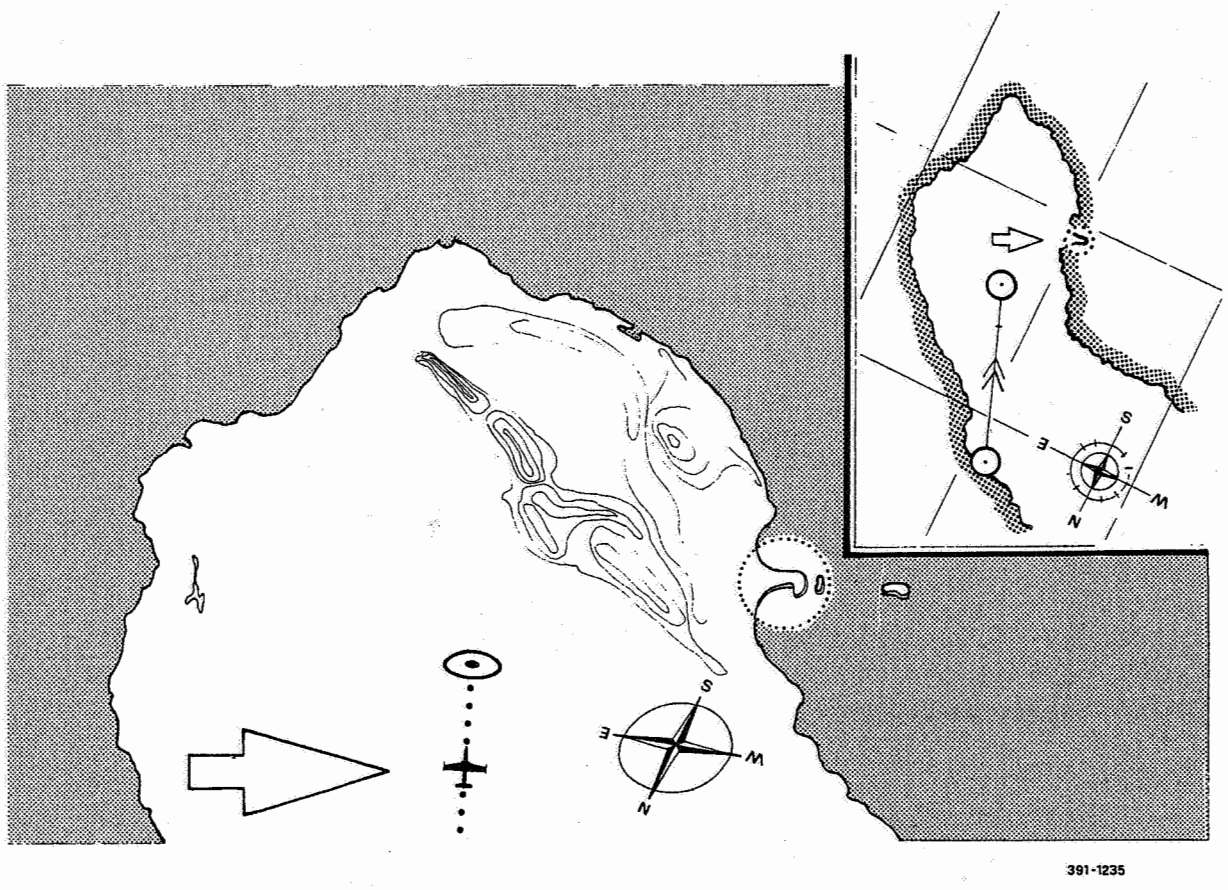


Figure 11-12. Map Orientation

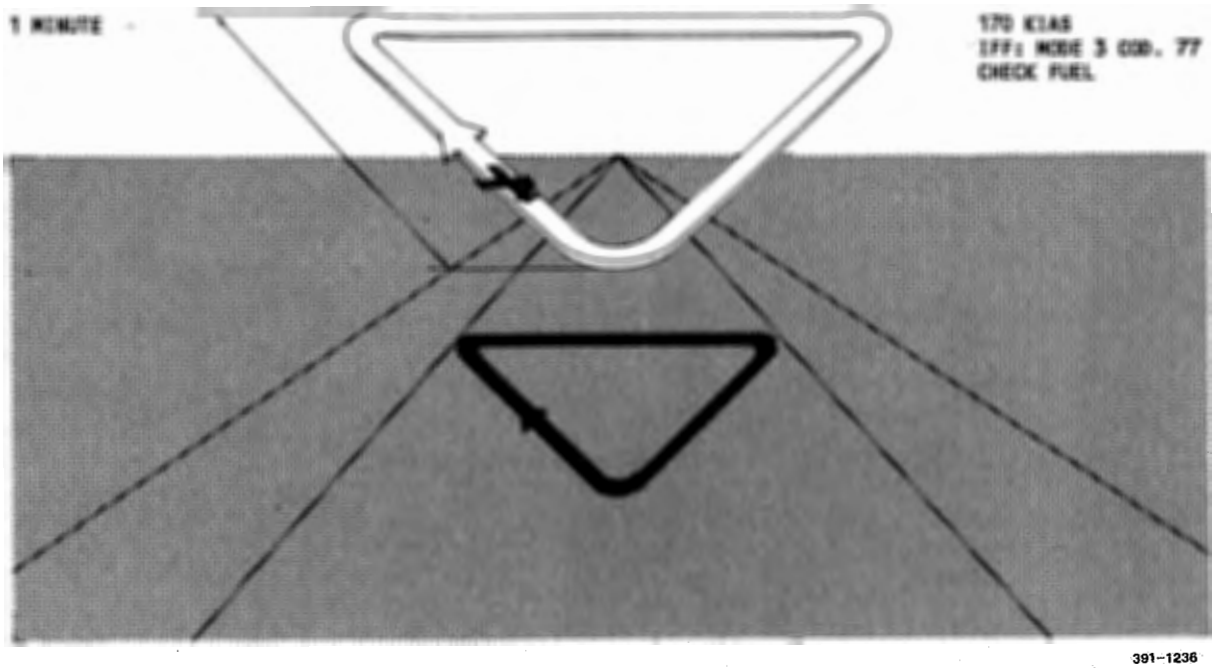


Figure 11-13. Triangular Circuit "Lost Pilot"

- Fuel check is very important in case of pilot's disorientation.

(4) Adverse weather conditions. When it is impossible to fly farther in VMC and in visual contact with the ground (though changing flight level), it is advisable to reverse course and return to the departure airport.

(5) Alternate airports. The selection of these airports had been done during flight planning, giving consideration to: routes, distances, times, fuel consumption from destination airport to the alternate airport.

(6) Prohibited areas. These areas must be located during planning. Make always sure that your flight path does not bring you to overfly these areas. In case of doubts, or if locating these areas accurately is impossible, contact the concerned air traffic control activity.

(7) Air traffic. Carefully observe all rules that govern flight, be they temporary or permament.
It is essential that the surrounding airspace be constantly and attentively cleared, in particular when intersecting airways, changing flight level or entering controlled areas.

g. Mental Planning

If for any reason one or more navigation legs must be changed in flight, it is essential that the pilot be prepared to organize a new flight planning in the shortest possible time, availing of mental calculations.

(1) Mark a new line or fold the chart along line A B to join the sheet new checkpoints (A and B) on the chosen new course (fig. 11-14, sheet 1).

(2) Calculate the approximate magnetic headings using the compass cards printed on the chart or considering the cardinal points and interpolating to identify the most probable angular value (fig. 11-14, sheet 2).

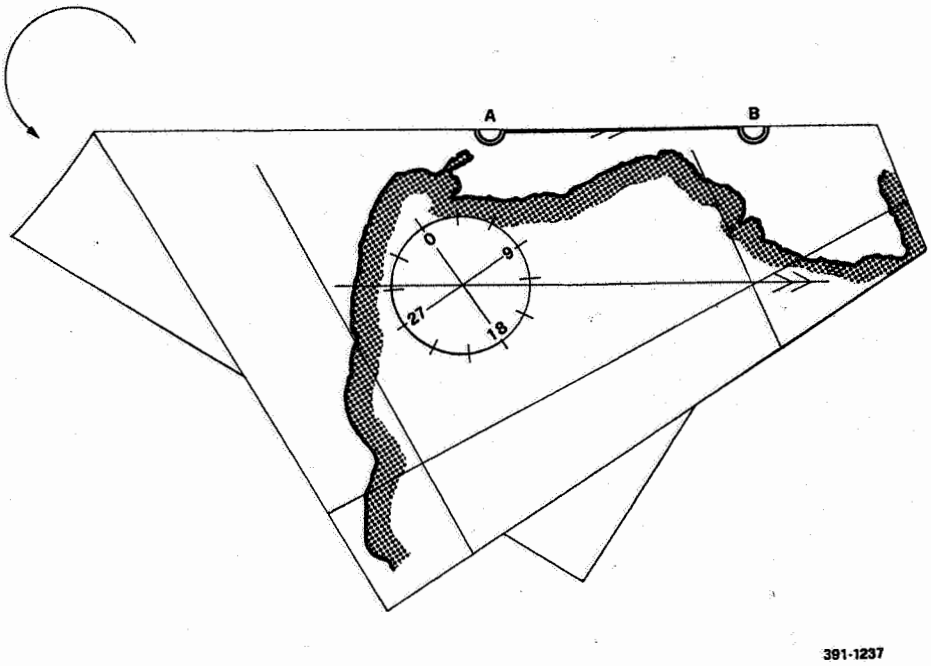


Figure 11-14. Fold Map Along Line AB (Sheet 1 of 2)

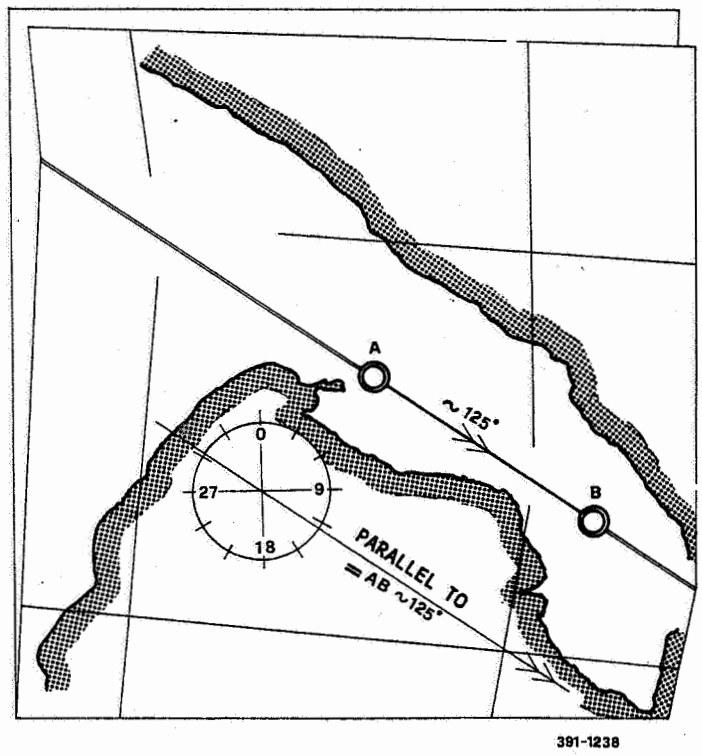


Figure 11-14. Open Up Map and Estimate Course Angle Visually (Sheet 2 of 2)

(3) To determine the approximate distance, use the hand, a pen or any other object that can be rapidly and positively found, as a reference (fig. 11-15).

(4) Find safe enroute altitude and chose the flight level according to the semicircular levels rule

(5) Maintain the last IAS used for navigation.

(6) The time in minutes required to cover a leg having length D (nautical miles), measured by reference to the one that was approximately measured in (3) along a meridian is:

$$t \cong \frac{D}{IMN \times 10}$$ (IMN = Indicated Mach Number)

and, in turn $IMN = \frac{KTAS}{600} = \frac{KIAS + 4Q}{600}$ (Q = altitude in thousands of ft).

(7) Overhead every checkpoint (fig. 11-16), carry out the normal checks and procedures concerning:

- Time over checkpoint
- Turn to new heading
- Safe enroute altitude on new leg
- Estimated time to next checkpoint
- Estimated fuel (consider the fuel comsumed in one minute, read the fuel flowmeter, at a given percent RPM and altitude, then multiply the data by the number of minutes of envisaged flight time)
- Estimated time to the next checkpoint and estimated time of overflying (ETO).

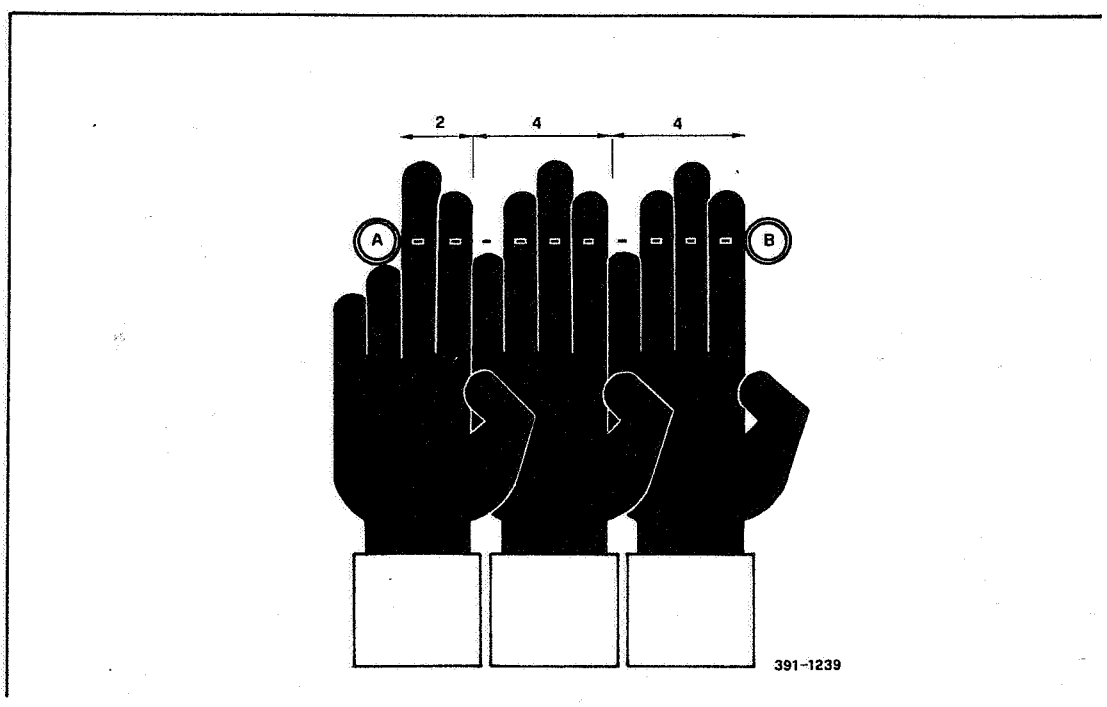


Figure 11-15. Approximate Measurement of Distance

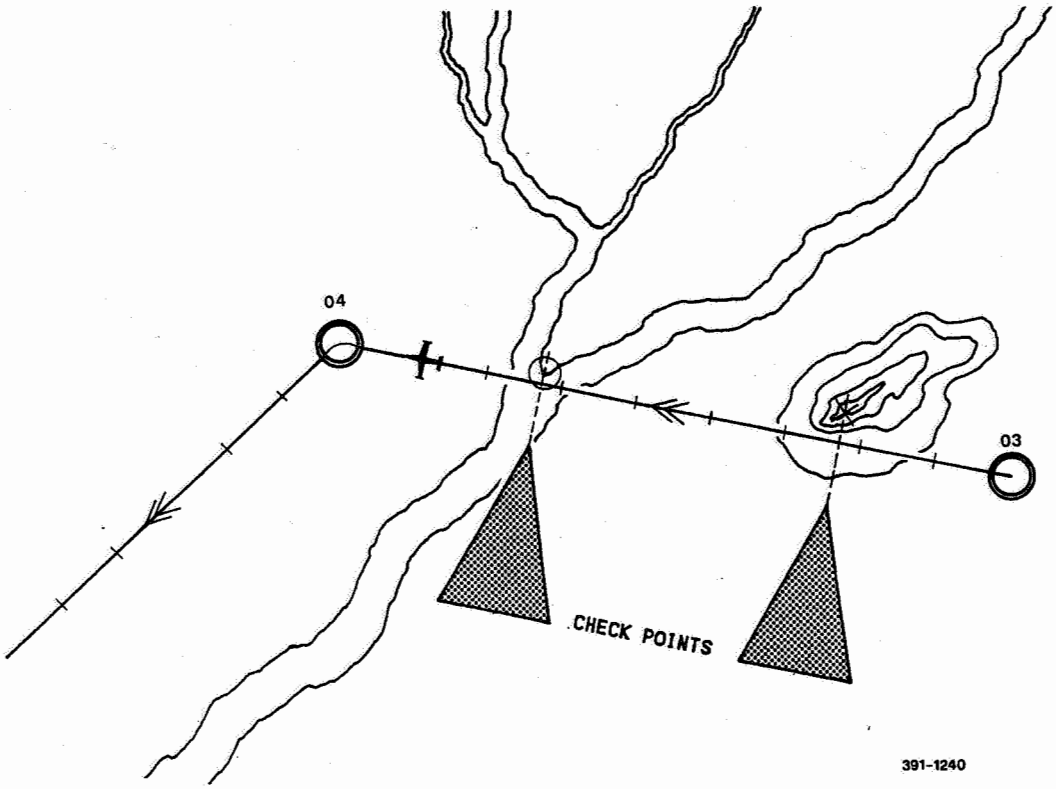


Figure 11-16. En-route Check Points

3. VERY LOW ALTITUDE NAVIGATION

a. General

Very low altitude navigation is the navigation flown at the minimum possible altitude above ground level (from 150 to 2000 ft) in dead reckoning mode (compass, clock, airspeed indicator, visual check of main checkpoints on the ground).
The characteristics of very low altitude navigation are essentially safety and surprise.
When operating at this altitude it is in fact possible to avoid the radar detection and make it difficult for the enemy to determine the attack direction. Enemy fighters interception and attack at low altitude are difficult and if consideration is also given to how complicated it is to aim the surface weapons, it is easy to understand why this type of attack is so effective.
A rapid pass over the target at very low altitude even if it is well defended, is nowadays the less risky method of attack because very low altitude and very high speed are critical parameters for the anti-aircraft artillery, and create difficulties also for the missile defended positions, including those provided with missiles designed to oppose low attitude attacks.
The very low altitude missions are usually carried out to attain different objectives:

- Armed visual reconnaissance over free (opportunity) targets
- Missions (attack or photographic) against specific targets
- Launch of supplies or paratroops

The altimetric profile of these missions depends essentially on the safety and surprise factors, meteo conditions and fuel consumption, which is inversely proportional to altitude.
The problems faced when flying very low altitude missions, especially below 1000 ft AGL, depend on the typical difficulties of this flight, which is conducted at high speed, and on psychological reasons. Special care is to be paid in the selection of the checkpoints that will have to be easily identifiable.
In general, the causes that negatively affect the very low altitude flying are:

(1) Turbulence

(2) Wind changes due to orography

(3) Reduced field of view

(4) Impossibility of using the radio aids

At very low altitude, to the field of view limitations and the aircraft high speed, there adds up the difficulty of identifying the checkpoints, as they appear in a perspective which is completely different from the one of the chart and the one with which they are seen when flying at altitude. For instance, a village which can be easily identified from overhead because of its peculiar shape, the layout of connection roads, the rivers flowing in the surroundings or across it, becomes difficult to recognize at very low altitude and high speed. Therefore, to successfully complete a very low altitude mission, the flight must be carefully planned and perfomed.
Herein there are indicated the basic principles to be adhered to both during flight planning and flight, definitions, and used symbology and the typical parameters applicable to the MB-339A aircraft.

b. Planning of a Very Low Altitude Mission

(1) General information and rules

(a) Very low altitude navigation is essentially a dead reckoning navigation (DR).
As known, in this type of navigation the pilot must assess the aircraft estimated position with respect to a point which is overflown at a given moment.
This estimate depends on three factors:

- Indication of the airspeed indicators, altimeter, compass and clock
- Estimated wind data (or wind computed in flight)
- Last fix

If the estimated (or computed) wind parameters are correct, magnetic headings marked and held accurately, if envisaged speed is maintained and no deviation occurs enroute, then it is rather easy to fly the planned course.
The above are however ideal conditions (fine weather, precise instruments, accurate piloting), that rarely occur.

More often, the flight plan and navigation must be modified basing on new positions and as a result of inaccuracies to comply with the parameters. Therefore all available aids (RNAV, radio, radar, etc.) must be used to supplement DR navigation.
In a tactical fighter flying at very low altitude over an enemy territory, position must necessarily be determined either by visual means (reading of the chart and observation of the terrain), or by use of airborne equipment (RNAV, PHI/Doppler, PHI/Inertial Nav, Navigation radar,

etc.). When flying with the aid of the RNAV, a mix between DR navigation (by electronic means) and visual navigation is obtained.
The basic principles described in this paragraph are therefore applicable to very low altitude navigation flown with the aid of the RNAV.
In this case, after choosing the checkpoints basing on their visual prominence, their bearing and distance from radio aids that could prove useful during navigation will also be determined. Only the planning method based on visual checkpoints on the ground will be taken into consideration herein.
Planning of very low altitude missions with the aid of the RNAV (also, and especially in the DR mode without TACAN) is dealt with in the Navigation and Instrument Flying manual.
The so flown very low altitude navigation is therefore based on DR and visual navigation. Headings, airspeeds and times are adhered to along planned courses (dead reckoning navigation), groundspeed and actual flight path are conversely determined on the basis of checkpoints (visual navigation).

(2) All very low altitude navigation missions must be planned in conformance with military general and local directives.

- Very low altitude flight courses must comply with the orientation of the envisaged air corridors if they exist (fig. 11-17).

- If it is necessary to cross a corridor with a heading different from the allowed one, the aircraft must climb to an altitude higher than 2000 ft AGL and conform to the VFR.

- Course must not affect areas subject of permanent or temporary restrictions nor controlled and hazardous areas (TMA, CTR, ATZ).

- Flight altitudes must ensure an actual separation of 1500 ft from the ground for training missions and 500 ft AGL for operational missions, and must remain at least 1000 ft below the minimum usable altitude of the airways above.

- Overflying of areas inhabited by more than 5000 people, of turism and beach localities, crowded zones and industrial complexes should be avoided.

- If overflying the mentioned areas cannot be avoided, the minimum altitude must be 1500 ft above the highest obstacle.

- Very low altitude navigation missions must be flown in VFR and at any rate with visibility in excess of 3 km outside the controlled areas (5 km inside these areas).

- If it is impossible to fly VFR along the planned course, it is permitted to slightly deviate from it provided the pilot conforms to the orientation of corridors, airspace restrictions and prohibition to overfly.

- It is permitted to overfly controlled and hazardous areas only prior clearance from the responsible ATC.

- If, to maintain compliance with the VFR, it is essential to climb to a higher altitude, the aircraft must contact the responsible radar net that will provide the applicable instructions.

- In case of an emergency during very low altitude navigation, the aircraft must remain in contact with the responsible radar net which will provide immediate assistance and will carry out the necessary coordination with the different concerned activities to bring the aircraft back to the departure base or divert it to the alternate airport.

- The airborne altimeter must be set on the QNH of the stations that are closer to the overflown area. QNH is informed by the Airport Weather Station before take-off.

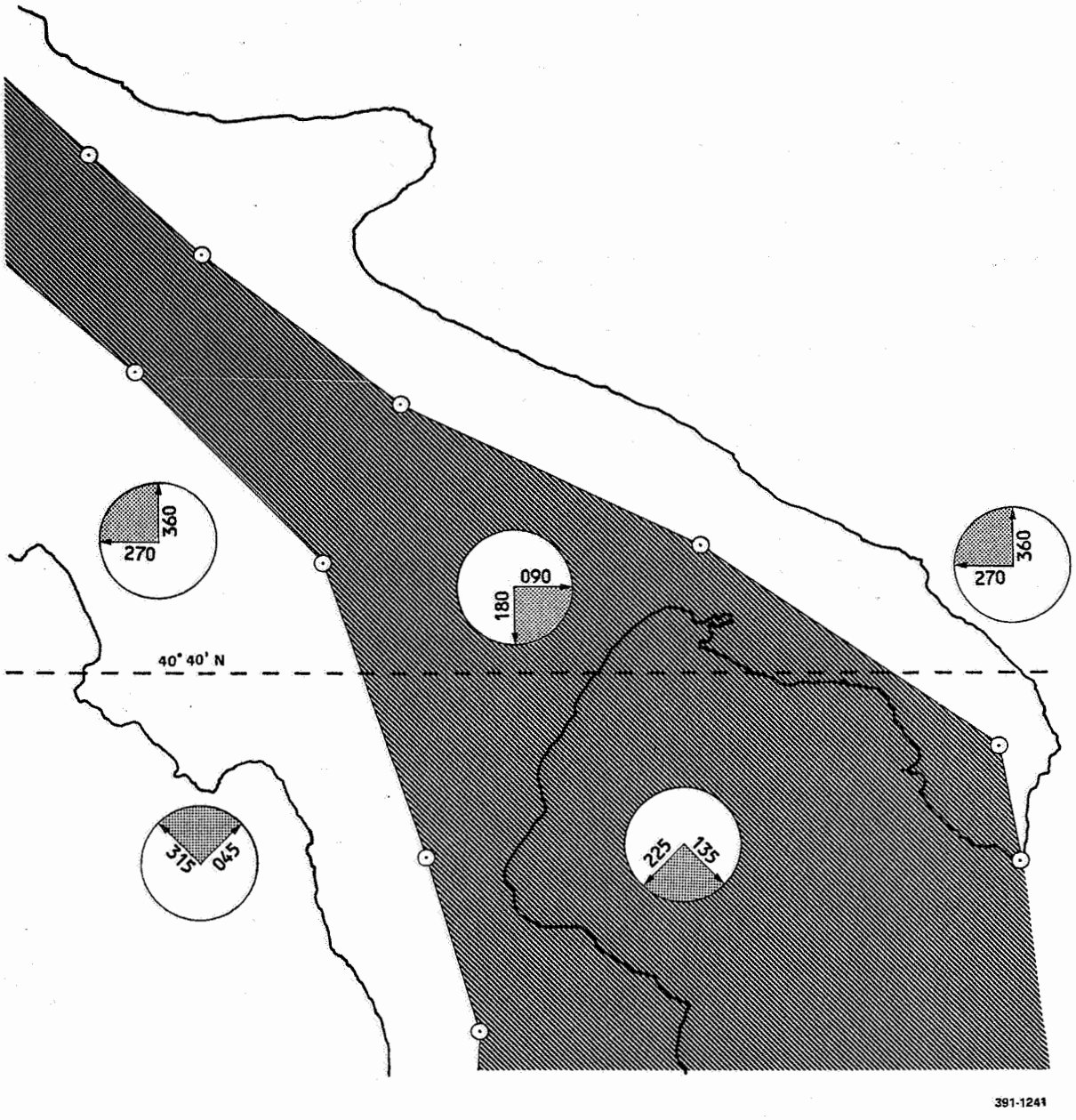


Figure 11-17. Examaple of Air Corridors for Very Low Altitude Navigation

- IFF/SIF is used according to the applicable regulations.

(2) Preliminary preparation. The material necessary for the preparation of a very low altitude navigation is as follows:

(a) Aeronautical charts in scale 1 : 500 000 and 1: 250 000 (Tactical Pilotage Chart - TPC).

(b) Charts of the target area in scales 1:100 000, 1:50 000, 1:25 000.

(c) Scissors, glue, navigation plotter, rulers, plotting material.

(d) Aircraft performance tables.

(e) Standard symbol templates.

(3) Determination of course. It is accomplished by examining in detail and on the suitable charts first the target area (1:500 000, 1:250 000 charts, down to the charts in 1:25 000 scale), and then the terrain to overfly to reach the target.
All updated information concerning danger area and obstacles must be marked on the charts.
In the selection of landmarks it must be considered that the terrain features at low altitude sometimes show very peculiar aspects or contours, and that useful distance to recognize them is often 1 or 2 miles only.
The basic criteria applicable to landmark selection during the planning of a training mission at very low altitude are as follows:

- To avoid passage in proximity of airports open to traffic;
- To avoid overflying inhabited areas;
- To avoid overflying sea far from shore
- To avoid overflying danger areas or prohibited areas
- To avoid making too long legs not to pile significant errors
- To avoid as far as possible that the angle between two subsequent legs is larger than 20°
- To take into account the corridors established for very low altitude navigation by the applicable regulations

c. Training in and Familiarization with Very Low Altitude Navigation

The very low navigation flights of military student pilots have the purpose of familiarizing them with the piloting techniques and with planning and conduct of operational flights.
Therefore targets to be overflown will be established at a given time (TOT = time over target), or "attack time", although acceleration to Mach 0.7 before the initial point and actual attack are not envisaged.
Turns will be flown with 45° bank and turn radii will be considered even if the turn radius of the MB-339A is less than half the turn radius of the combat aircraft.
For both initial training very low altitude missions and aerotactical very low altitude missions, it is suggested that "Tactical Manual" PI AD-02-39A and the "Instrument Flying and Navigation Manual" PI AD-03-39A which deal with the subject in greater detail, be examined.

d. Determination of Peculiar Points

(1) Examination and selection of a training target. In the real case the target is a place or installation on the ground that is important from the tactical viewpoint and is "rewarding" from the viewpoint of a very low altitude air attack.
It must be reached from the most favourable direction to obtain the best results (hits) and to keep losses to the minimum. (anti-aircraft artillery and missiles). During the very low altitude familiarization missions, the target must be reached from the most favourable direction giving consideration to its characteristics and to the way of making recognition the easiest.

(2) Determination of run-in. This leg must take into account some parameters that derive from the type of attack that it is desired to fly.
The importance of a good choice of the run-in leg to obtain good success in the armed attack or photographic reconnaissance cannot be overemphasized.
This is the reason why this leg must be short in order to avoid errors, and must be chosen in a way to permit a nearly straight flight and, in

the real case, acceleration to maximum speed (dash speed) before reaching the initial point.

(3) Determination of the initial point. The initial point, that is the point at which run-in is commenced, is the most important point of the whole navigation and therefore must be recognizable beyond any doubt. It is pointed out that the route from the initial point to the target must allow a straight flight of at least 3 minutes (18 to 25 NM for the MB-339A).

(4) Determination of the turning points. Tactical and navigation reasons recommend that legs should have a length between 30 and 45 miles. Easily identifiable landmarks must therefore be selected (ex. mountains, isles, railroad crossings, mouths of rivers, lakes, etc.) between two subsequent navigation legs. These landmarks are termed turning points.
During navigation planning, it is essential that the radius of turn be calculated if between a leg and the following one a turn covering a sector of more than 45° is to be flown (lateral displacement greater than half a mile).
During planning, the radius of turn is graphically determined by using round templates, which, suitably applied on the turning point, will indicate the lateral displacement of the aircraft.
This value can be determined also by use of the following formula:

$$\frac{\text{TAS (m/sec)}}{g \times \text{tang } \beta}$$

where β = banck angle

g = gravity acceleration (9,81 m/sec^2)

NOTE

From the formula applicable to centripetal acceleration, which is:

$$a_c = \frac{V^2}{Rv} \text{ or } FC = \frac{V^2}{Rv} \text{ from where } Rv = \frac{V^2}{Fc} = \frac{V^2}{g \times \text{tang } \beta}$$

Use the conversion tables from knots to m/sec (figure A1-8 of "Performance Data Manual"), to obtain V in m/sec.

For a bank angle of 45° tang β = 1 thence R (meters) = $\frac{V^2}{9,81}$,

if V is in m/sec, if conversely V is in kt, R = $\frac{V^2}{4,767}$

e. Determination of Flight Data

(1) Courses. To obtain this data it is sufficient to join all turning points and measure their angles on the chart. When turns between two subsequent legs cover an arc longer than 45°, the aircraft turn radius must be considered, as specified above.

(2) Altitudes as already pointed out, very low altitude navigation is flown at 1500 ft AGL in case of training missions and 500 ft AGL in case of operational missions.
If inhabited areas are to be overflown, altitude must not be below 1500 ft.

It is also necessary to establish a minimum enroute altitude (MEA) for each navigation leg. This is marked on the folder and must be the navigation altitude to hold when marginal meteo conditions are encountered enroute.

(3) Fuel consumption. Once cruise speed and altitudes are established on each navigation leg, fuel consumption is calculated by referring to the performance tables (fig. 11-18 and 11-19) and considering the following items in the sequence.

- Configuration (drag index D.I.)
- Maneuvers on the ground
- Take-off and acceleration
- Cruise
- Acceleration to dash speed
- Attack
- Inbound course

NOTE

For ease of reference, specific range and endurance of the MB-339A aircraft in clean or ferry configuration at low altitude (1000, 2000, 3000 ft ASL) with different outside air temperatures from ISA-20°C and ISA+20°C are given in figures 11-18 and 11-19, together with an approximate indication of % RPM and flowmeter fuel flow indication (kg/minute).

For the MB-339A in clean configuration Drag Index = 0
For the MB-339A in ferry configuration (2 underwing tanks) Drag Index = 50. For information only: the drag index is the percent increase of the clean aircraft aerodynamic drag resulting from the carriage of the external stores.
For ground maneuver (10 minutes), take off and acceleration, fuel consumption is assumed to be 80 kg under all circumstances.

USABLE fuel is:
Clean aircraft: 1068 kg → to acceleration point: 988 kg
Ferry aircraft: 1559 kg → to acceleration point: 1476 kg
It is advisable to calculate the fuel bingo for the inbound course.
For training purposes, if acceleration to the attack Mach number and attack are not envisaged, the whole flight can be flown in cruise conditions.

CAUTION

If possible, avoid chosing a cruise IMN corresponding to the RPM percent range from 79,5 to 84%. In this range, the engine BOV could close or open continually, or remain open in the scarcely favourable region of the high specific consumption.
Therefore, in case of doubt, increase RPM and thence the Mach number.
The penalization in terms of specific range increasing
from Mach 0.40 to 0.50 is only 8%
from Mach 0.45 to 0.50 is only 5% } (aircraft clean)
from Mach 0.40 to 0.50 is only 11%
from Mach 0.40 to 0.45 is only 5% } (aircraft ferry)

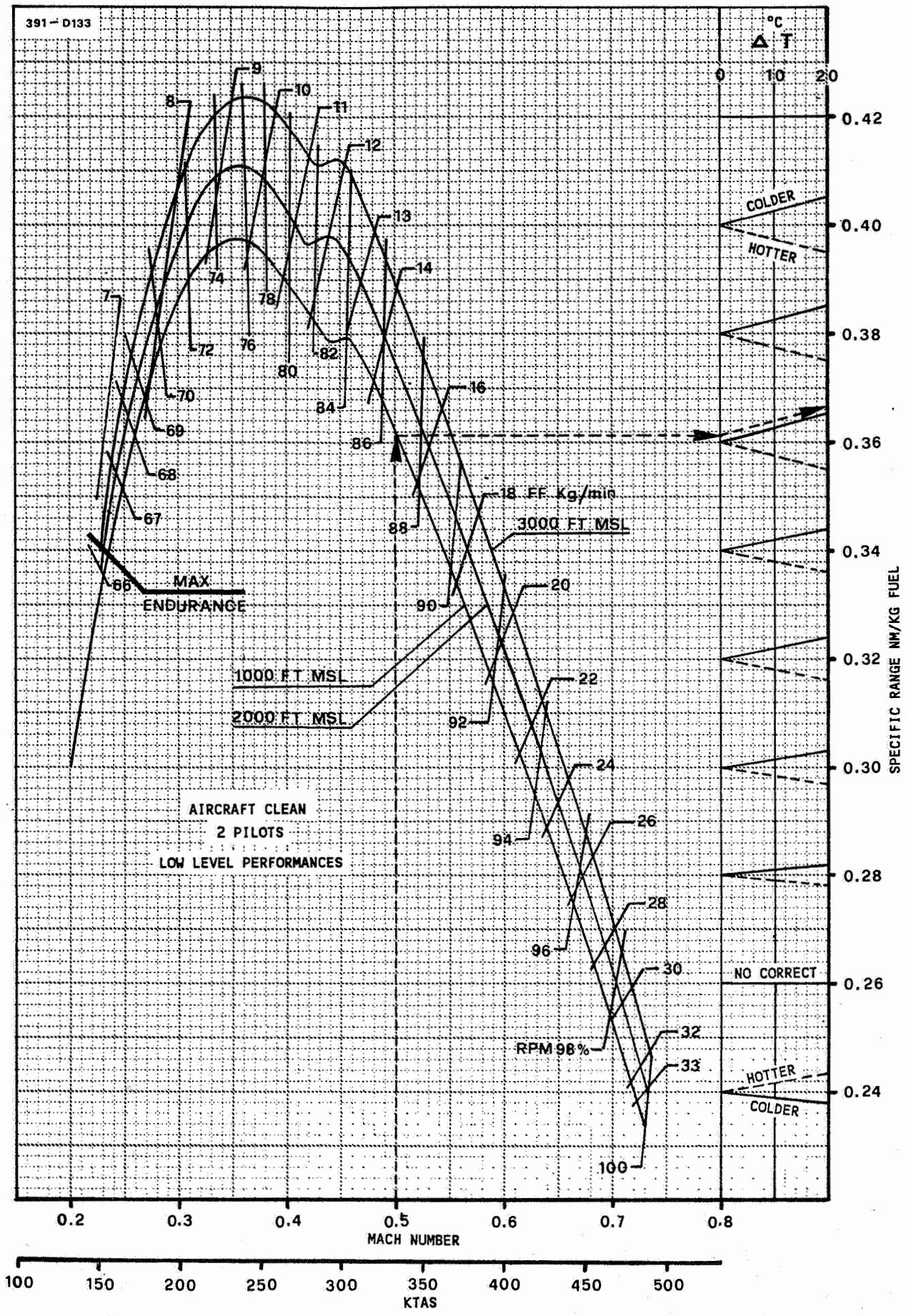


Figure 11-18. Very Low Altitude Missions With Clean Aircraft - Performance

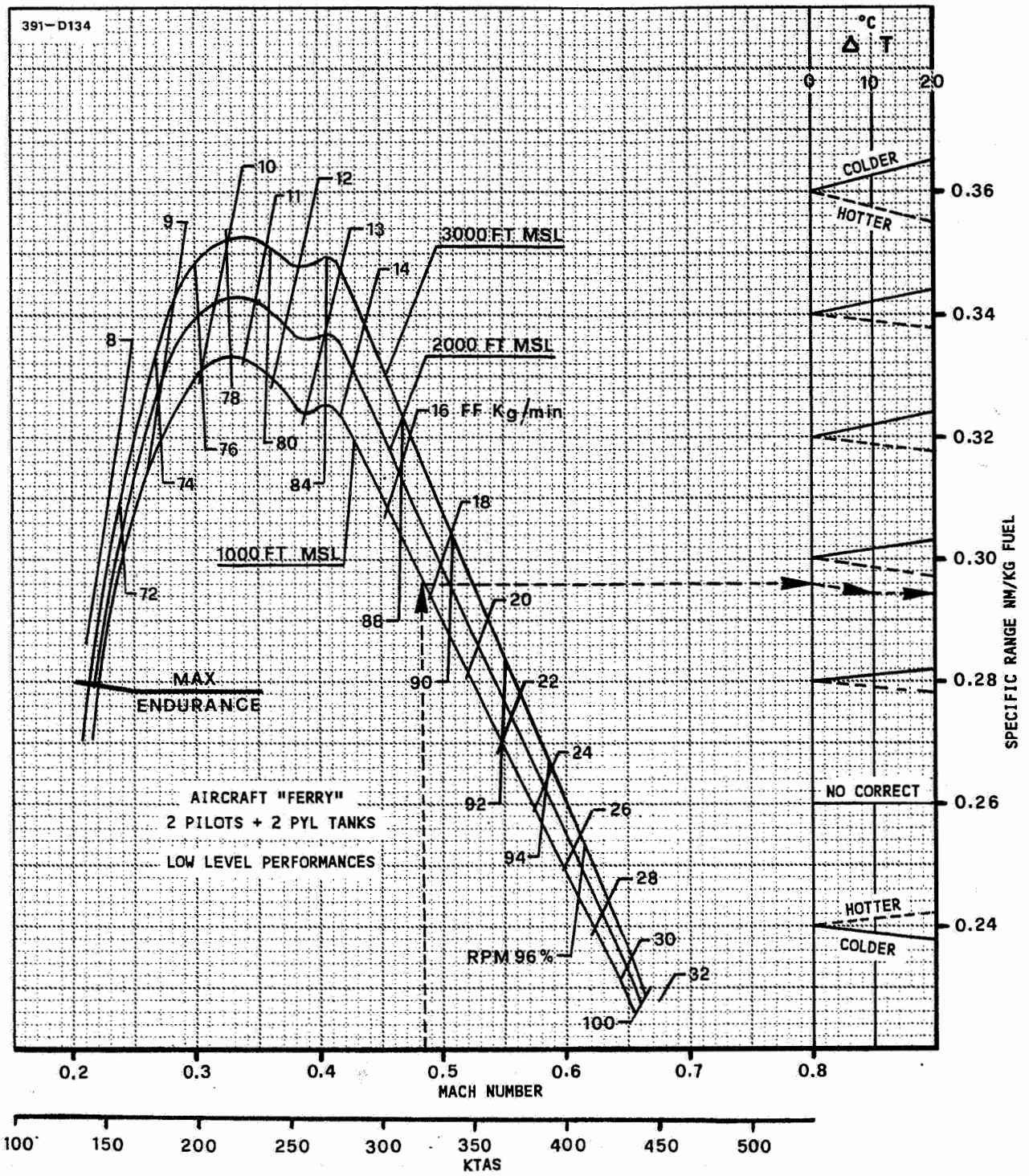


Figure 11-19. Very Low Altitude Missions With Aircraft in "Ferry" Configuration - Performance

4. STUDY AND PREPARATION OF VERY LOW ALTITUDE TRAINING MISSIONS

a. Premise

A complete training mission or a portion thereof that is flown at an altitude below 1000 ft AGL (1500 ft for familiarization training missions), outside the airport traffic pattern must always be preplanned and authorized by the responsible command (OPS office).
It must always be flown in VMC, outside controlled airspace and other areas in which very low altitude flying is prohibited. Apart from few exceptions, it must be coordinated at Air Region level in order to avoid having other squadrons concurrently flying very low altitude missions on the same course and at the same altitude.
Remember that below FL 50, or 1000 ft AGL, whichever is the highest, and outside airspace controlled down to ground level, the pilot is directly and exclusively responsible for the flight.

b. General Principles

The success probability of a wartime mission depends on the figther bomber pilot's ability to fly at the lowest possible altitude.
A well trained combat ready pilot is able to fly at 500 ft above the highest obstacle in that navigation leg, in IMC, provided the on-board instrumentation is adequate.
Since the acquisition of the special ability for the conduct of very low altitude operational missions requires a long and tough training, the very low altitude missions accomplished by the student pilot are flown in VMC at an altitude of 1500 ft AGL, for safety reasons.
The very low altitude missions are conducted by continuously and carefully monitoring the instruments (airspeed indicator, gyrocompass and clock) and by correcting basing on the visual identification of the landmarks of the overflown terrain.
Navigation errors due to inaccuracies of the airborne instruments are negligible, the errors caused by wind rather small. Conversely an incorrect piloting and the failure to stick to the preplanned parameters are the cause of remarkable, and occasionally unacceptable, navigation errors.

c. Criteria

The preparation of very low altitude missions and the flight conduct are completely different from the preparation and accomplishment of medium or high altitude missions.
The very low altitude navigation requires an accurate, detailed, complete planning of every element that can be used enroute, out of track, on an alternative course or during an emergency, bearing in mind that it is very probable that the flight is FLOWN WITHOUT THE RADIO AIDS.
In some instances, pilot's vision during very low altitude flying (hilly areas or tree covered terrain) does not exceed one km. This means that a checkpoint can be skipped because it is hidden in the landscape, if the aircraft is just one km out of track. This also means that a landmark is seen only 6 seconds before overflying.

d. Limitations

There is a limit to the pilot's possibility to look in and out in rapid succession.

The pilot's attention is nearly exclusively devoted to aircraft piloting on the outside visual references in positively difficult conditions due to orography and turbulence, which is nearly always present and is often severe at low altitude.
The time to read the instruments is very short, the time to read the navigation chart and flight card is the bare minimum.
There is no time for plotting, ... unless a very expert navigator is on--board.

e. Planning of a Very Low Altitude Mission

Already before planning, it is essential to decide whether the very low altitude mission will be aerotactical (simulation of a wartime flight), or a simple exercise to remain on track at low altitude.
The first very low altitude missions will be of the second type, and only after acquiring a sufficient experience, the pilot will have the possibility to go on aerotactical very low altitude missions.
Planning, the use of charts etc. will also be different depending on the type of mission flown.

f. Determination of the Most Convenient Airspeed

See para 3.e. above.
It is suggested to standardize for:
CLEAN CONFIGURATION = IMN 0.50 (325 KIAS)
FERRY CONFIGURATION = IMN 0.45 (295 KIAS)
that at 1500 ft AGL outside air temperature +25°C (average), result to be approximately applicable to most airports and barometric situations, and correspond to:
clean configuration: KTAS = 337 → NM/kg = 0,37 → FF15,5 kg/min → RPM 87% ca.
Ferry configuration: KTAS = 306 → 0,318 NM/kg → FF15,5 kg/min → RPM 87% ca.
During navigation, the value that must be kept constant is the MACH NUMBER (IMN). The other parameters will change slightly depending upon the environmental conditions.

g. Preparation of Navigation Charts (Non-Aerotactical Mission)

(1) Use charts in 1:500 000 scale (pilotage chart) or Tactical Navigation Chart (TNC). If possible, do not use the ICAO 1:500 000 charts that have not been updated for over ten years and are anyhow more suited to slow flying aircraft and navigation at medium altitude.

(2) Fold the chart accordionwise and possibly along parallels and meridians. Sometimes it can be more expedient to fold the chart still like an accordion, but in a diagonal direction, if the very low altitude mission is flown with this orientation.

(3) Open the chart again as shown in figure 11-20 sheet 1 and mark the courses as shown in para 2, using the standard symbology, but marking only the symbols that are necessary for the mission. Do not omit the symbols for COURSE, DISTANCE and FUEL CONSUMPTION to the alternate airports.

(4) At the point where underwing tanks and tip tanks are depleted, mark the following symbol, on the side of the course:

or

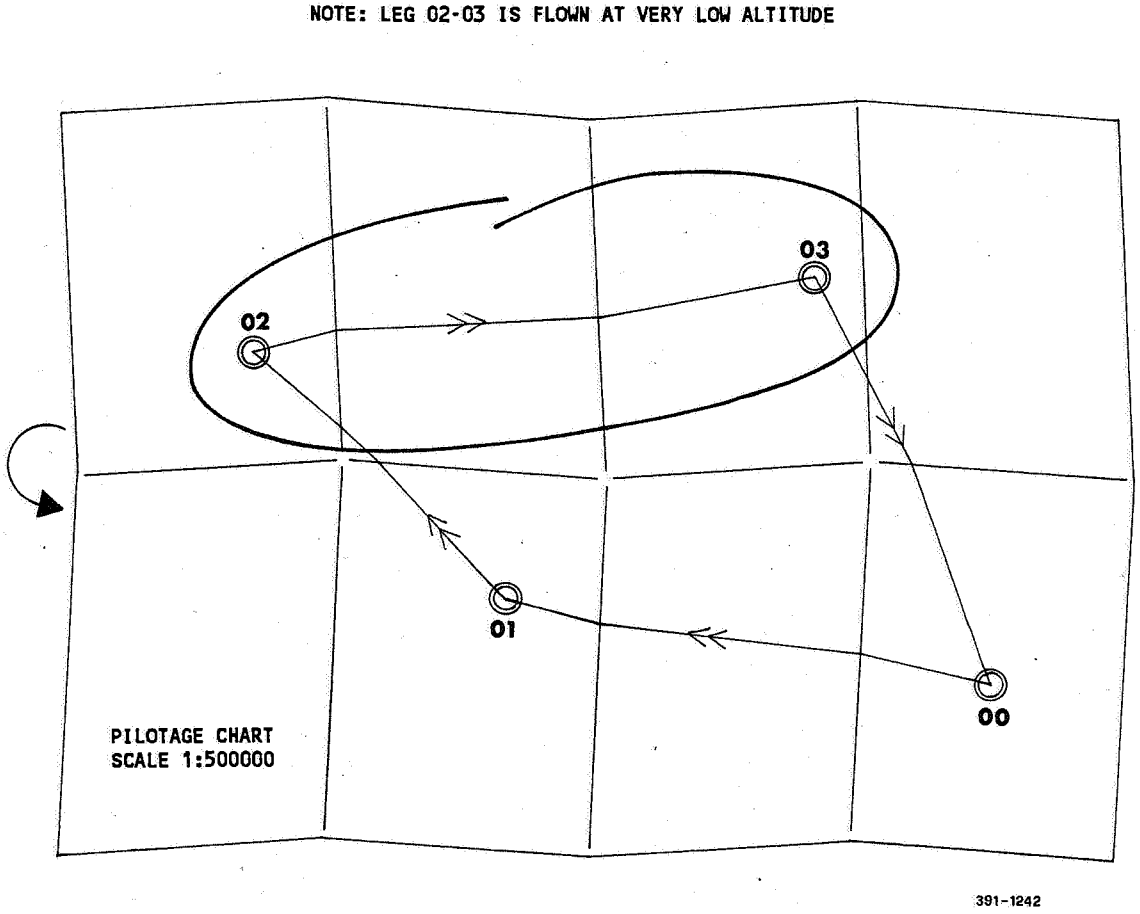


Figure 11-20. Plotting at a Low and Very Low Altitude Navigation Course (Sheet 1 of 2)

TIP TANKS DRY

Besides, if the mission envisages a return with remaining fuel low level, it is recommended that the fuel BINGO (minimum residual fuel) be marked at the second last and last navigation checkpoints, as follows:

MIN 280 Kg

or

MIN 235 Kg

(5) With the 1:500 000 chart, use a ruler obtained by transferring (or anyway exactly duplicating) the rulers shown in figure 11-24 using a stiff sheet of cardboard, plastics or plywood, etc.

(6) If necessary, write on the chart the diverging/converging lines for return on course (fig. 11-20, sheet 2).

h. Very Low Altitude Aerotactical Navigation

In the very low altitude navigation flights or during the very low altitude aerotactical navigation legs, waypoints must be overflown. Therefore, turn must not be commenced ahead of the waypoint, but exactly overhead the waypoint, while concurrently tripping the stopwatch.

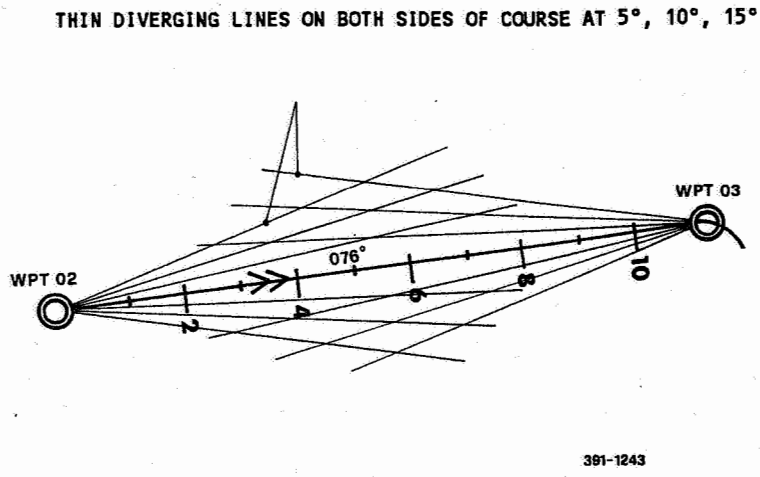


Figure 11-20. Plotting of a Low and Very Low Altitude Navigation Course - "Not Tactical" (Sheet 2 of 2)

Turns will be flown with a bank angle of 45° and turn arc must be marked on the 1:500 000 chart starting from the waypoint.
The new leg starts at the end of turn.
Marking of very low altitude flight path on the desired leg is obtained by placing the ruler tangent to the turn circle after the initial waypoint and to intersect the subsequent waypoint (fig. 11-21).

WARNING

The MB-339A installs a RNAV system displaying the TTG (time to go) to the pilot in DR mode too, with the approximation of one minute. The TTG can be used for a cross check with the stopwatch but is not a substitute for the elapsed time measured from the last overflown waypoint, as the accuracy of the stopwatch is one second.

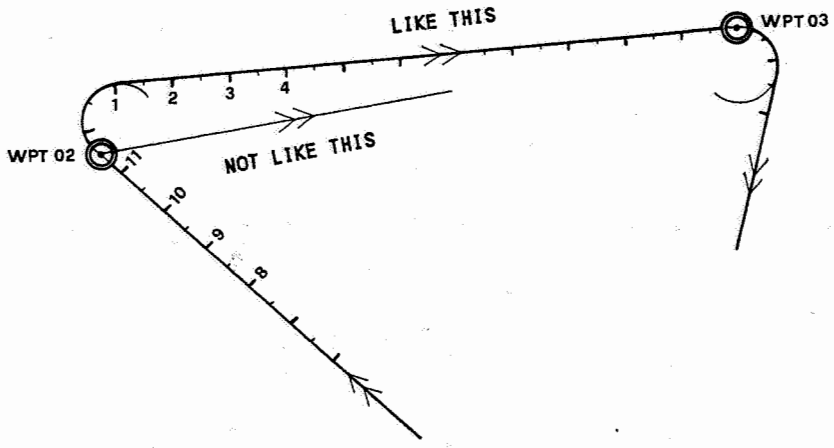


Figure 11-21. Plotting of a Low and Very Low Altitude Aerotactical Course

For the aerotactical very low altitude missions flown in the MB-339A to simulate an operational flight it is suggested to use:
Aircraft clean at Mach 0.50; KIAS 325, turn radius approx. 2925 m
Ferry aircraft, at Mach 0.45, KIAS 295, approximate radius of turn 2360 m.
The two rulers shown in full scale and for use with charts in 1:500 000 scale, apply to very low altitude flights with clean aircraft at Mach 0.50, and to ferry aircraft at Mach 0.45.
Turns with a 45° bank afford good maneuver characteristics, also in formation flying and do not require power setting changes. They do not distract pilot's attention, which is concentrated on terrain recognizance and obstacle avoidance, and do not cause remarkable IAS decrease during the turn. In figures 11-22 and 11-23 are reported turning radius. In figure 11-24 are shown low level navigation rulers.

i. Planning of Minimum Meteo Conditions

If miminum horizontal visibility for very low altitude training missions is 3 km, it is advisable to plan a check at some critical points of the course as follows:
.. From point X, point Y (which is 3 km away) should be at least visible on the side.
In case of rain, point Y should be located in the forward direction.
Cloud base must be at least 500 ft above the MEA.
In case en-route meteo conditions are worse than the planned minimums, the pilot must interrupt the very low altitude mission according to pre-planned modalities (generally, to climb to a pre-planned altitude and return to base).

MACH	TAS		INDICAT AIRSPEED	R_t^*	MACH	TAS		INDICAT AIRPSEED	R_t^*
IMN	KNOTS	M/SEC	KIAS	METERS	IMN	KNOTS	M/SEC	KIAS	METERS
0.30	197	102	193	1052	0.54	355	183	348	3409
0.32	211	108	206	1197	0.56	369	190	361	3666
0.34	225	115	219	1351	0.58	382	196	374	3933
0.36	237	122	232	1515	0.60	395	203	386	4209
0.38	250	129	245	1688	0.62	408	210	399	4494
0.40	263	135	258	1871	0.64	421	217	412	4789
0.42	276	142	271	2062	0.66	434	224	425	5093
0.44	290	149	283	2263	0.68	448	230	438	5406
0.46	303	156	296	2474	0.70	461	237	451	5728
0.48	316	163	309	2694	0.72	474	244	464	6061
0.50	329	169	322	2923	0.74	487	251	477	6402
0.52	342	176	335	3161	0.76	500	277	490	6753
(*) RADIUS OF TURN WITH 45° BANK									

Figure 11-22. Radius of Turn as a Function of TAS

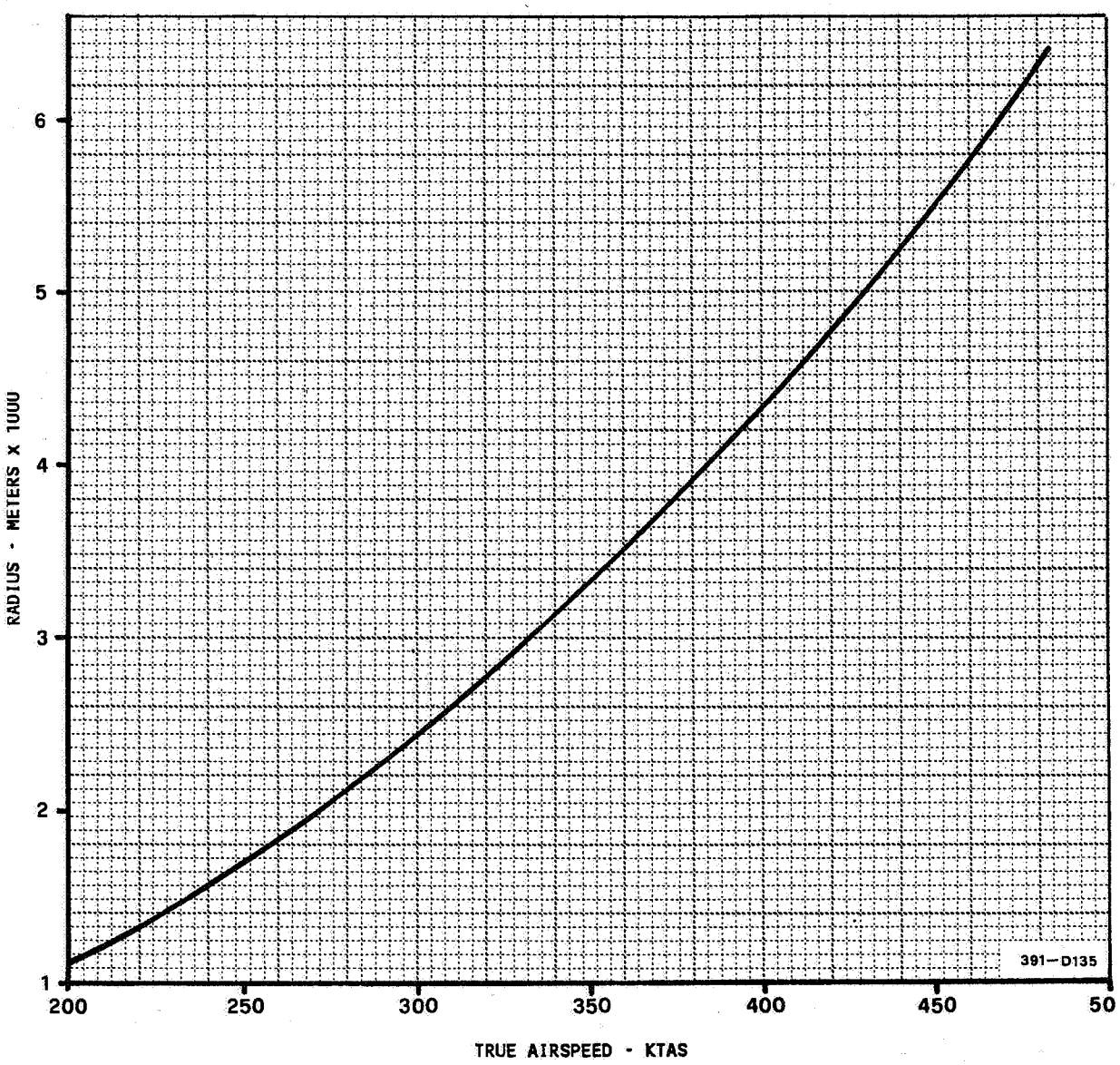


Figure 11-23. Radius of Turn With 45° Bank

j. Planning of En-route Checkpoints

In addition to the turning points selected as indicated in para 3.d (4), it is advisable to choose some points along the route, parallel to it, or abeam of the route. Also these checkpoints must be clearly and unmistakably identifiable in flight.

k. Preparation of the FOLDER

If deemed advisable, didactical very low altitude navigation can be prepared beforehand by the Training Office who will make ready a flight log, a RNAV card and a folder for each mission. The folder includes PC's and TNC's cut and arranged in the same way as those included in the Operational Folders used by the operational units (excluding, if they are not of interest, the details of the target area in scale 1:250 000).

(1) Folder. This is a specifically prepared booklet including all elements needed for navigation conduct to the target and inbound course.

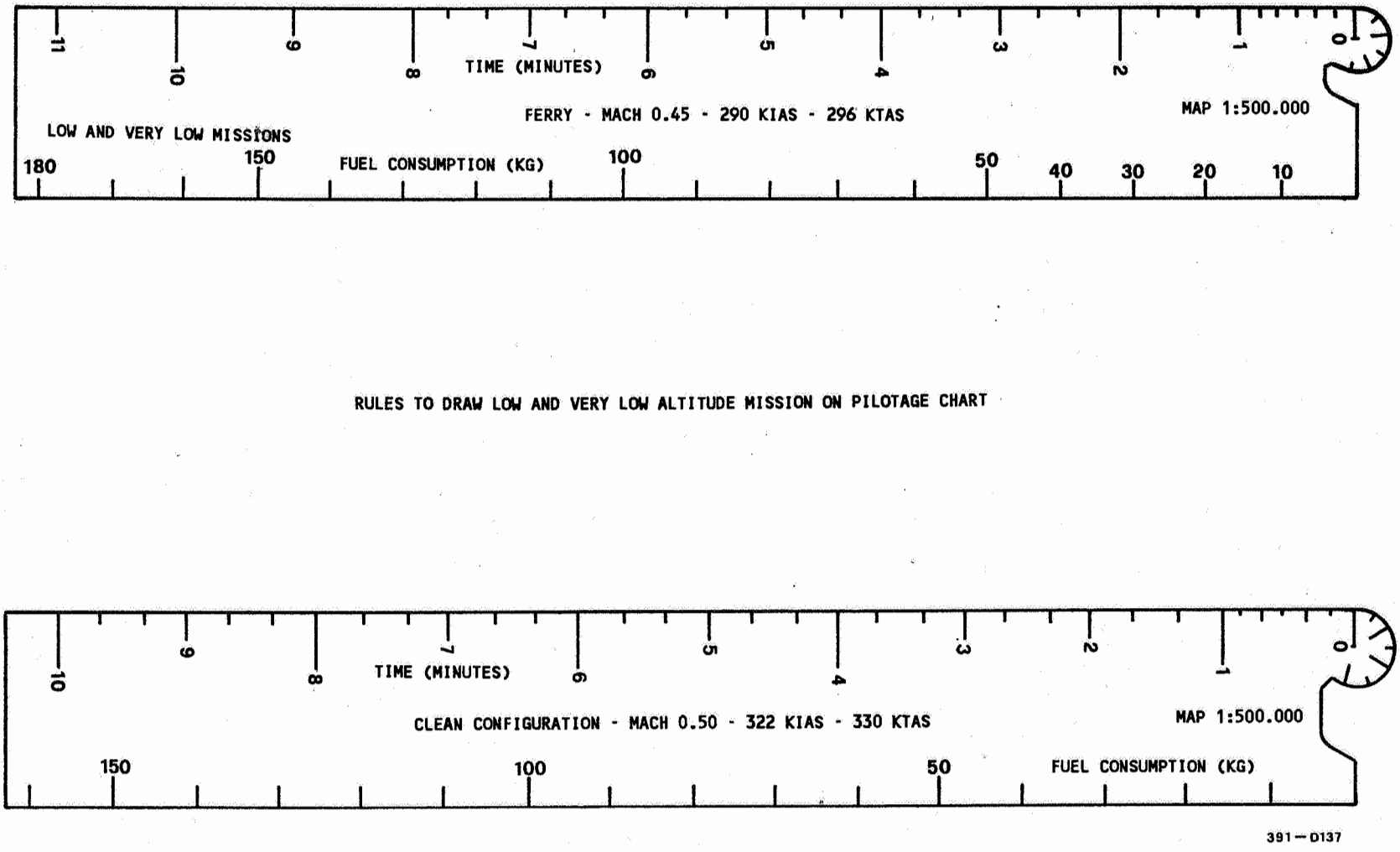

TIME (MINUTES)
FERRY - MACH 0.45 - 290 KIAS - 296 KTAS
MAP 1:500.000
LOW AND VERY LOW MISSIONS
FUEL CONSUMPTION (KG)
RULES TO DRAW LOW AND VERY LOW ALTITUDE MISSION ON PILOTAGE CHART
TIME (MINUTES)
CLEAN CONFIGURATION - MACH 0.50 - 322 KIAS - 330 KTAS
MAP 1:500.000
FUEL CONSUMPTION (KG)
391—D137

Figure 11-24. Rules for Low and Very Low Navigation

Military Directives specifies in detail the characteristics the folder must possess. These characteristics refer to dimensions, types of maps to be used (1:500 000 for the navigation legs, 1:250 000 or 1:200 000 for the target area), to the elements to indicate on the external and internal covers, the symbology to adopt, etc.
All charts must be cut to make a folded strip of 17 x 17 cm.

(2) Standard symbology (fig. 11-25).

(a) Departure point (usually marked as WPT 01). The Departure Point (DP) must be indicated by a 1 cm radius circle, with its center on the concerned point. It is particulary important, and may coincide with the departure base or with an easily identifiable point that must be no more than 3 minutes of flight away from the brake release point; it is the point at which navigation begins.

(b) Turning points. These points are marked by a 1 cm radius circle too. The course lines never cross its contour. If marking is made on the folder, the initial and final circles of each page will include inbound direction arrows and outbound turning direction for the subsequent leg.

(c) Orbit point. It is a well identified point where an aircraft is required to orbit while awaiting further instructions. It belongs to an elongated pattern that starts at a point that is easy to locate visually and that is possibly identified and marked as a waypoint.

(d) Course lines (fig. 11-26). The line joining the different turning points is the course line. It exactly joins the centers of the circles, but, if the turn radius must be calculated for the subsequent leg, the joining line will start from a point tangent to the circle arc marked on the chart.

(e) Time marks. The time marks must be perpendicular to and at the right of the course line, in accordance with the preplanned groundspeed.

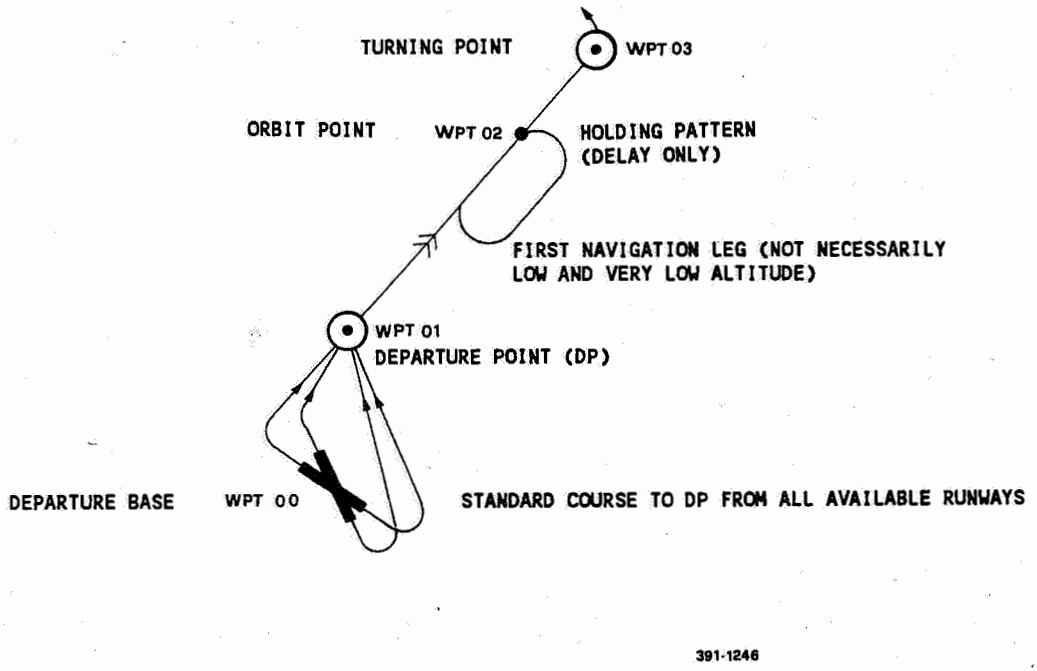


Figure 11-25. Start of Aerotactical Navigation

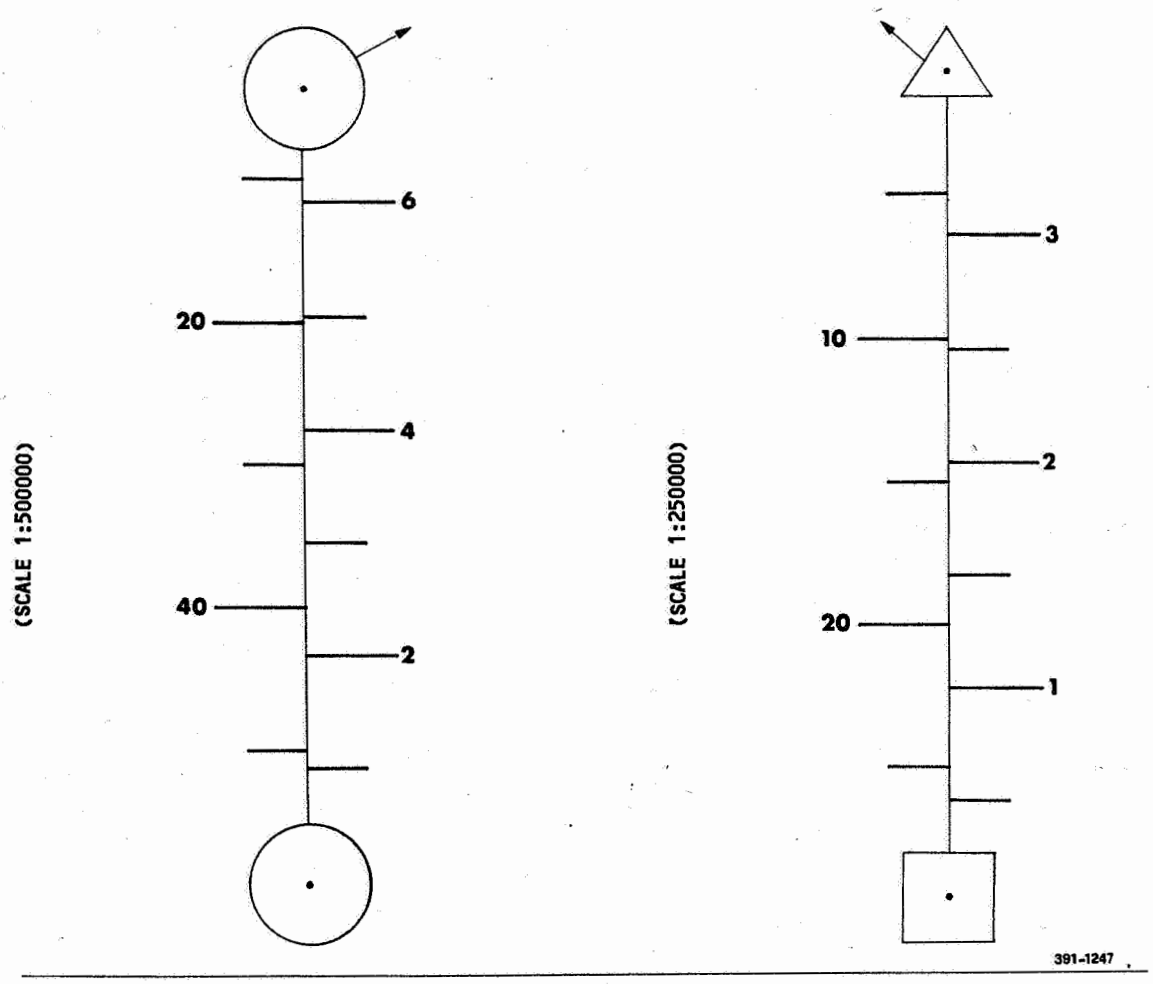


Figure 11-26. Course Lines on Folder

Time must be calculated from brake release, but must be first marked on the initial leg after the departure point, in increasing values.
Time calculation must be commenced over each checkpoint, overhead which the pilot must trip the stopwatch. Time marks must be traced on the different scale charts in the following way.

- 1:500 000 scale chart. The marks on this type of chart will be in 1 minute intervals. Marks of even minutes will be 1,5 cm long and bear the relevant number, while the marks of the odd minutes shall be 1 cm long and not numbered.

- 1:250 000 scale chart. Time marks on this type of charts will be in 30" intervals; the marks of full minutes will be 1,5 cm long and numbered, the 30" marks will be 1 cm long and not numbered.

(f) Distance marks. The distance marks will be placed normally to the course line and on its left. The distance to travel on each leg must be decreasing between two checkpoints. Distance marks must not be indicated on the course line from take-off to departure point. Distance marks are different depending upon the type of used chart.

- 1:500 000 scale chart. Distance marks must be traced every 10 NM distance. The marks of all even -ten distances (20, 40, 60, etc.) must be 1.5 cm long and numbered, while the odd-ten distance marks (10,30, 50, etc.) must be 1 cm long and not numbered.

- 1:250 000 scale chart. The distance marks must be traced every 5 NM. All marks of even distances (10, 20, 30 etc) will be 1,5 cm long

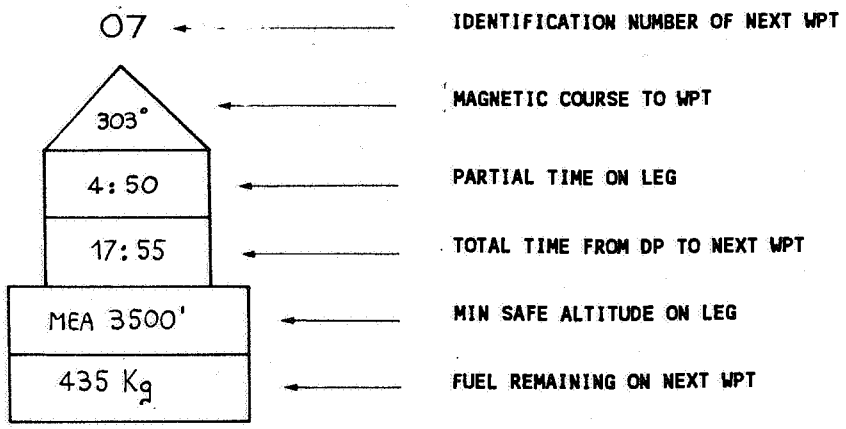


Figure 11-27. Course Arrow Box

and numbered, all odd distance marks (5, 15, 25 etc.) will be 1 cm long and not numbered.

(g) Navigation data arrows. This is the box containing the most important data for each leg and is located on the right of the course, 3 cm away from it, parallel to it and in the forward direction.
The box is divided in several sections each containing some data as shown in figure 11-27.
The IMN, percent RPM and RNAV input data, the frequencies of radio aids, radio-communication channels, etc. must not be marked on the chart, but on the special flight log.

(h) Course and distance information box. This is a rectangular box containing the magnetic heading information and distance to the next waypoint.

It is located on the upper part of the leg and must be oriented according to the heading of the subsequent waypoint (fig. 11-28).

(i) Minimum en-route altitude (MEA).

- Minimum enroute altitude is intended as the lowest altitude at which a weapon system can fly in full safety from one point to another when the weather conditions are marginal.

- It will obviously be higher than the planned altitude at which the low altitude mission is flown under normal conditions.

- The MEA must be entered in the arrow box and is mandatory at the beginning of each leg; in the latter case a suitable symbol is placed at the left of the course line; it refers to the entire leg, from one turning point to the next, and represents the highest MEA of the leg (fig. 11-29).

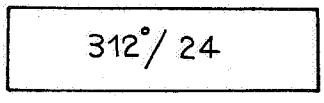


Figure 11-28. Course and Distance Box

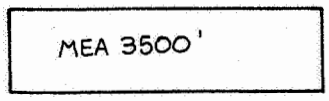


Figure 11-29. Minimum (IFR) Altitude on Leg

It must also be marked everytime altitude varies significantly, as for instance when course is set from sea to a high shore, or over large mountain lakes.
In all these cases, it will be marked ahead of the point where it changes.

- MEA corridors are parallel to the course line and, for the training missions they are 10 NM wide on both sides of the course, and at an altitude of 1500 ft AGL. In operational missions on the contrary, they extend 5 NM on both sides of the course at an altitude of 500 ft AGL.

(j) Calculation of the MEA. To determine the MEA it is necessary to refer to the symbols on the chart, where obstacles are delineated with contour lines, or dots (.), or "x" (X), or the typical symbol for antennas. The applicable elevation is indicated opposite each symbol.

- Elevation of a dot (.). To the elevation indicated with a black dot, add the vertical elevation error of the chart (100 ft for TPC's, no error for TNC's); then add 500 or 1500 ft, depending on the type of mission, and round-off the result to the next 100 ft up (fig. 11-30).

- For all other elevations (contours, obstacles, vertical heights, elevation of a point marked with an x), refer to the examples given herebelow. Consider maximum elevation and add half the interval between two contour lines (in case of reliefs), then add 500 or 1500 ft depending on the type of mission and round-off the result to the next 100 ft up (fig. 11-31).

(k) Initial point (fig. 11-32). The initial point (IP) is represented by a 1.5 cm square placed parallel to the forward direction; it is used to indicate the last turning point before the target (target of the very low altitude navigation).
From this point on no changes of speed are permitted and navigation must be very precise and accurate.
Generally, the flight portion from the IP to the TGT is drawn on a 1:250 000 scale chart.

(l) Target. The target (TGT) is represented by an equilateral triangle having 1,5 cm side and the vertex in the forward (attack) direction. An arrow indicates the run-out direction (fig. 11-33).

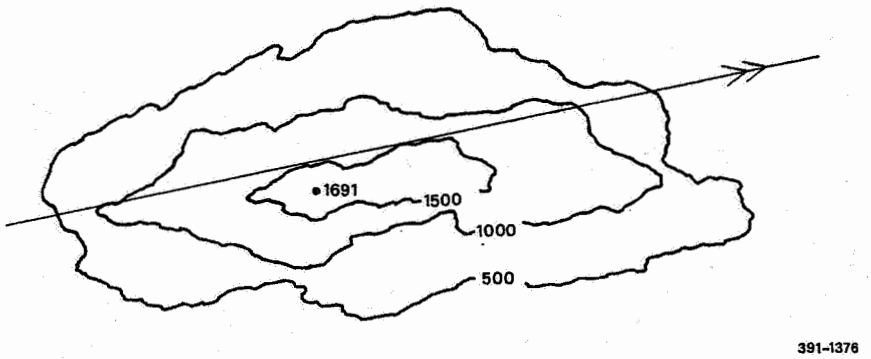
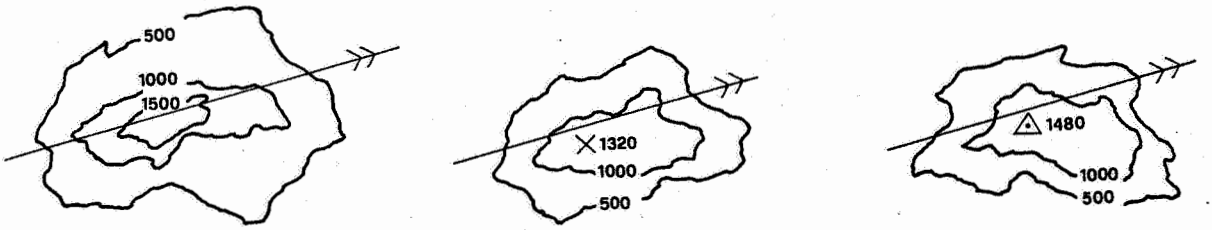


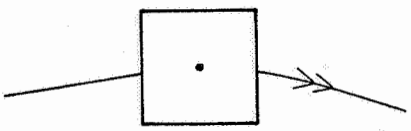
Figure 11-30. Calculation of MEA, Elevation of one Point

ELEVATION OF POINT X	1320 +
HALF INTERVAL BETWEEN COUNTOUR LINES	320 +
SAFETY MARGIN	500 =
	2070 FT
VIZ: MEA	2100 FT



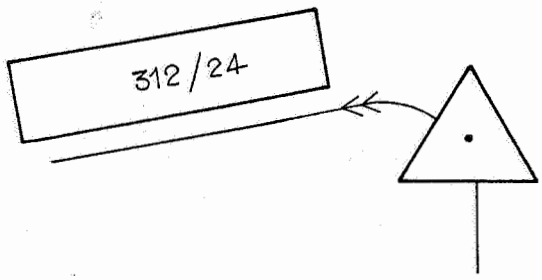
ELEVATION OF COUNTOUR LINE	1500 +	ELEVATION OF OBSTACLE △	1480 +
HALF INTERVAL BETWEEN COUNTOUR LINES	250 +	HALF INTERVAL BETWEEN COUNTOUR LINES	250 +
SAFETY MARGIN	500 =	SAFETY MARGIN	500 =
	2250 FT		2230 FT
VIZ: MEA	2300 FT	VIZ: MEA	2300 FT

Figure 11-31. Calculation of MEA



391-1320

Figure 11-32. Initial Point



391-1321

Figure 11-33. Target (TGT)

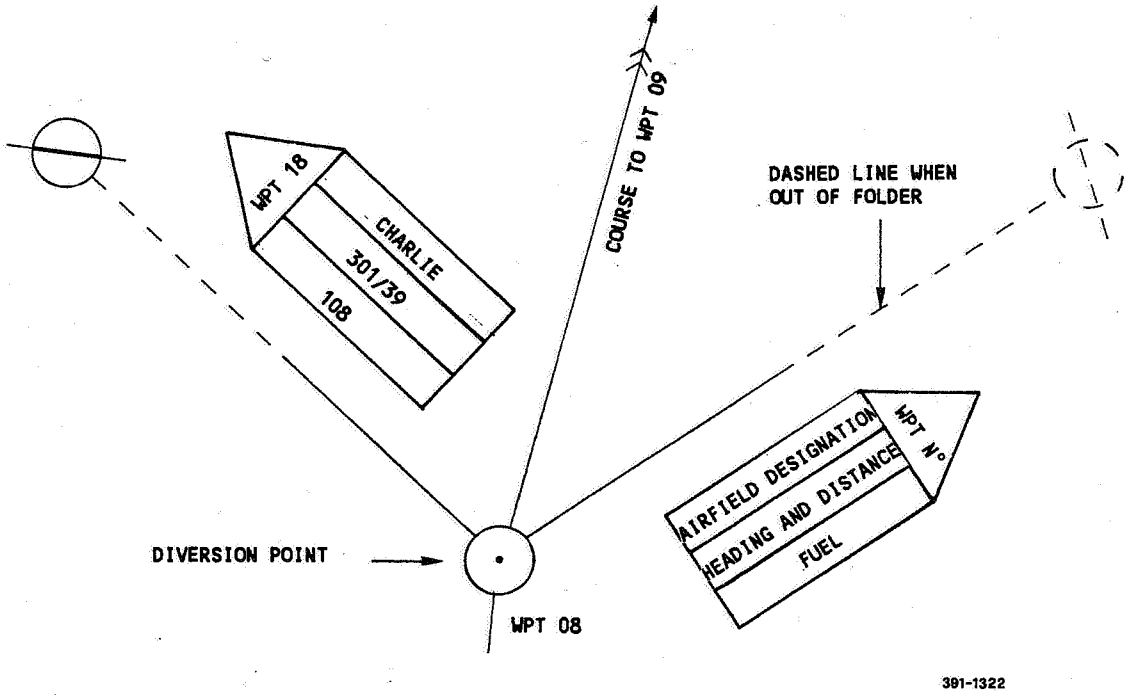


Figure 11-34. BBQ Standard Symbols for Diversion to Alternate Airfields

(m) Alternate airports. The alternate airport symbol consists of a circle intersected by a diagonal line.
The information related to the alternate airports is enclosed in an arrow located parallel to the heading both when this information applies to pre-established points of the course and when it indicates a direction starting from the planned diversion point (fig. 11-34).
The following information is given in the arrow:

- Name of airport
- Distance in Nm to reach this airport from the diversion point
- Magnetic heading to the airport
- Required fuel

(n) True north. On every portion of the course, therefore on each page of the folder, there must be marked the true North: this will be made by use of an arrow enclosing a letter N (fig. 11-35).
Information arrows:
In this box there are given all navigation operative instructions, i.e. level-off, descend to ..., climb to ..., armament check, IFF/SIF, radar STBY, pylon jettisoning, accelerate to ..., pull-up point, etc. This symbol is marked at the left of the course line and the arrow must be located where the relevant actions must be taken.

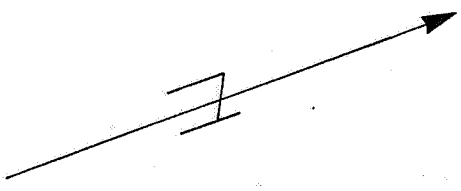


Figure 11-35. North Arrow

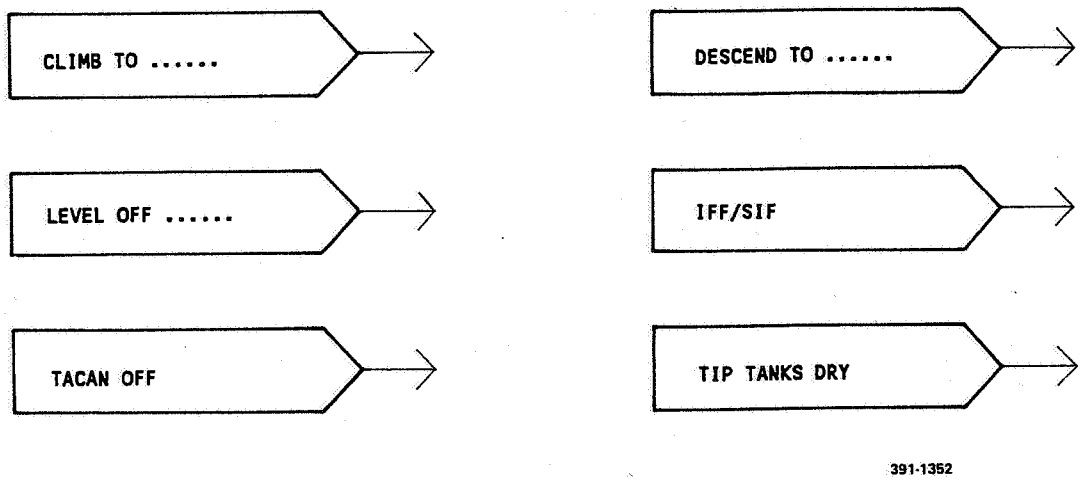


Figure 11-36. Standard Symbols - Information

All symbols, including the strips of times and fuel consumption, can be cut in acrylic plastic templates, to facilitate and speed up the preparation of the folder (fig. 11-37 and 11-38).

5. PERFORMANCE OF VERY LOW ALTITUDE TRAINING MISSIONS

a. Critical Analysis of Course and Folder

The success of a very low altitude mission is largely determined by a serious, accurate and deep-going study of all significant details of the target and navigation landmarks.
In particular, the path between the initial point and the target must be thoroughly known, because even a small mistake in this portion of the flight may cause the mission to fail.

(1) Analysis of the course. During mission briefing, the course must be analyzed on the folder to locate and memorize the most significant checkpoints permitting the position to be identified on the terrain and compared with the planned course.

Following the course trace on the chart, large and conspicuos terrain features are identified, the location of which helps find smaller landmarks, still on the chart.
These large features can be: a mountain, a lake, a river, a town, etc. Located on the side of the course they generally provide to convey the attention to small and peculiar landmarks, such as a road crossing, a bridge, a bend in a river, a confluence, etc.
In a word: a technique that could be termed "the funnel technique", should be implemented: that is observation, is from general to detail, from large to small.
The lower the navigation altitude, the narrower the "funnel", as the pilot's field of view restricts when flight altitude decreases; while a reduction of visibility is also involved.
Checkpoints are selected so as they are one or two minutes flying time apart. A well trained pilot will however continuously monitor the flight path development on the ground references.
When the large visual references are chosen, it is advisable to adopt the following criterion: prefer "continuous" terrain features, i.e. refer to a river, a valley, a mountain range developing along the course rather than to a village, a town, etc.

The former elements in fact follow the pilot all along his course, whilst the latter provide an occasional, momentary and not always reliable check; a village in fact can easily be confused with another one if no natural features are available to differentiate and characterize it.

(2) Take-off time and preliminary operations. A take-off time is not assigned for the first missions, but later on as training progresses, a take-off time can be assigned, which is to be observed with a tolerance of one minute.
Before going to the aircraft, it is essential to know the value of the minimum QNH enroute (that will be entered in the altimeter), and the areas possibly temporarily prohibited because of artillery fire, parachute jumps, etc. (NOTAM's).

- During the checks in the aircraft, it is essential to verify the correct operation of the airborne stop-watch.

- On the runway, and perfectly lined up on its centerline, check that the gyro compass (HSI) reads the actual value of the QFU, and note possible deviations.

b. Flight Conduct

(1) Measuring the time. Time measuring starts either from brake release or from an established point called hack point or departure point. It is obviously necessary to take into account the time taken from brake release to the departure point with reference to the take-off direction.

(2) Position check. Very low altitude navigation is based on the assumption that the pilot knows exactly his position.
The check of the visual references on the ground permits the correction of errors and the check of total and partial times.

(a) Use of visual references. The visual references, that are chosen during the flight planning phase on the ground, must be sufficiently away from one another and easily identifiable also in poor visibility conditions.
Very large references are usually very useful to permit location of smaller references that are in turn used to determine the aircraft position. This involves the implementation of the already mentioned "funnel technique", which shifts the attention from the larger to the smaller landmarks. To do this, the following criterion should be adopted: by referring to the chart, locate a large terrain feature along the planned course approx. 30 to 40 seconds before reaching it, then look out to identify this point on the terrain.
Then locate the related small landmark on the terrain and check position with respect to it. If required, carry out course corrections.
It is not advisable to continuously look for the terrain landmarks and chase them with continuous heading, attitude and airspeed variations, in the same way as it is not advisable to search landmarks already recognized on the terrain on the chart: in this way position check would not be made in advance, but late.

(b) Correction technique. Once the actual position has been established, it is not advisable to get back on course by flying sharp turns: this would involve a loss of speed and thence excessive power setting changes and fuel consumption.
It is conversely advisable to locate a point farther ahead (about 40 to 50 seconds) and point toward it.
If this is impossible, return on course should at any rate be made avoiding sharp maneuvers.

(3) Time checks. Time planning is performed by considering speed

constant and zero wind. In reality conversely the flight may develop ahead of or behind schedule, and this situation must be corrected as soon as possible. It is therefore necessary to slightly change speed to adhere to schedule.
There are many ways to do this: the simplest is the following: "Increase or decrease the airspeed by 30 kt or 1/10 Mach suitably changing power setting and maintaining the new airspeed 1 minute for every 5 seconds of error, then restore cruise speed with the same procedure used for the previous variation".
When adopting the above method, it is useful to establish the minute of the partial time in which the correction is completed, in order not to incur in the opposite error maintaining the correction for a longer time than required.
If you are ahead of time by, say, 15 to 20 seconds, it is convenient to remain so, whilst it is always advisable to immediately recover even a few seconds of delay.
Eventually, corrections of total time are not performed in the flight portion between the initial point and the target in order not to complicate the situation in this particular portion of the flight.

(4) Flight altitude. In VMC, the altimetric profile of the terrain is followed at an altitude of 1000 ft over the highest obstacle in a strip of 10 NM on both sides of the course. Consideration must always be given to the mean enroute altitude.
If a climb to clear a relief is required, start the maneuver with a lead to be able to maintain a rate of climb not higher than 2000 ft/min. Fast altitude changes bring about speed errors, thus time errors, and an increased fuel consumption as a result of the attempt to hold the speed parameter.
During these changes, both in climb and in dive, increase or reduce the Mach No. by 0.01 every 4000 ft altitude, or the IAS by 5 kt every 1000 ft altitude.

(5) Turning point. The turning point is determined visually or on the clock.
It would be useful if the turn point could be identified at least 2 NM before overflying to avoid too many turns to reach it, which would result in time errors for the subsequent leg. Therefore, in the last 30 to 40 seconds of each navigation leg, attention should be nearly exclusively devoted to the search and identification of the Turn Point.
Once the turn point has been identified, heading shall be set to overfly it, avoiding sharp turns. If the position is not known for sure, heading must be maintained until the time allocated for the leg has elapsed, then the turn to the next leg will be flown.
Only if the Initial Point is not recognized, it is necessary to return to the last known checkpoint. Overhead the turn point:

- Set to zero than start again the second counter for partial time
- On the accrued time stopwatch (if available) check whether ahead of or behind schedule
- Turn with a 45° bank to the new leg
- When new heading has stabilized, check remaining fuel
- When turn has been completed, check heading on the gyrocompass for consistency with standby compass

(6) Initial point. The last turn point before the target is also defined as the initial point and is the most important point of the whole navigation: the attack phase in fact starts on it.
It is necessary to overfly the initial point with the extreme accuracy and it is essential that all course errors and time errors have been already removed.

(7) Approach to target (run-in). In this phase, navigation must be particularly accurate.
No time correction is made in this section, because both gross errors cannot be made up for, and it is necessary to concentrate the attention on navigation to maintain heading and speed.
In the very low altitude student missions, this flight phase is flown in cruise conditions and the target is overflown in level flight.

(8) Return to base. The inbound navigation must be conducted according to the same modalities and techniques implemented for the outbound course. This means that the same accuracy must be maintained because flight is not yet over and in the real case, the aircraft is over enemy territory, and the pilot must watch out for enemy reaction: his life and aircraft are very important also after attack has been completed.

c. Considerations and Suggestions

(1) The very low altitude navigation missions, or the very low altitude portion of a mission, must be flown with the aid of the stopwatch and possibly with the TACAN and VOR sets off, thus with the RNAV in DR mode.
It is therefore required to make a RNAV FIX over each overflown waypoint of the very low altitude navigation leg, as indicated in the following step 7.

(2) Terrain landmarks along each leg, on the course or abeam of it, must be checked by taking the time from the last overflown waypoint, over which the stopwatch must be restarted. Lateral deviations with respect to the enroute checkpoints must be corrected by estimation, possibly enforcing the following rule: correction = two times the error.

(3) Adjust overflying times by increasing or decreasing airspeed as clarified in para 5.b (3), and not by widening turns or trimming corners. It is necessary to be slow in correcting a ahead of time condition and prompt to correct a delay.

(4) The pilot should be mentally prepared to see a specific landmark on the track or a little away from it, but within the pilot's field of view at a given instant; (note: field of view is not visibility: a reference may be hidden to the sight by a hill, vegetation, etc.).
A cross-check between chart and stopwatch is essential. It is also necessary to learn to estimate the distance (sidewards) from a checkpoint which is not along the route using the length of the runway of the home base as it appears from aloft as a reference.

NOTE

> The way of reasoning, viz the "MENTAL DR" to which the pilot must get used is as follows: "in 40 seconds I must see on my right side a shed with two silos at a distance of two runway lengths"

(5) Lateral references beyond 4 km on the side are useless to remain on route, but can be used to check time.

(6) In the real case the time over target (TOT) must be complied with accuracy, to attack the target from different directions in a quick sequence.
To match time, it is necessary:

- To zero and restart the stopwatch when overhead each waypoint, paying particular attention when on the initial point. At the same time another stopwatch (or the other hand on the double stopwatch), will be

used to measure the total flight time; it should also be borne in mind that matching the TOT is important for mission fulfilment.
Do not trim corners or widen turns.
In case of wartime missions, course changes may bring the pilot over positions well defended by missiles and automatic anti-aircraft artillery.

- Check time from the departure point to the last turn point, as well as points abeam of the course or points at 90 degrees or approximatively at 90°, with respect to the course.

(7) If flying with the RNAV in DR mode in the immediate vicinity of a RNAV WPT, it is necessary to zero the DR mode errors; this is effected by a fix operation, as follows:

- When approaching the WPT, press the keys "FCN" and "FIX"

- Head to the WPT as soon as it is spotted

- Exactly overhead the waypoint press the "ENT" key, set to zero and restart the stopwatch, and concurrently turn towards the next waypoint

- Using the HSI heading set and course set knobs enter heading and course to the next waypoint

- After completing the turn and when heading has steadied, press the "WPT" and "xx" keys on the CDU panel ("xx" is the number of the subsequent waypoint), and the "USE" key

- Start the cross check: HSI-map-outside world, correct the course errors and adjust power to have actual time coincident with planned time.

6. VERY LOW ALTITUDE AEROTACTICAL NAVIGATION RULERS (fig. 11-37)

Aermacchi prepared a clear plastic ruler to facilitate tracing of the very low altitude aerotactical routes on charts or mission folders ONLY in scale 1:500 000.
In addition to permitting the flight time and the fuel consumption to be marked, the ruler is cut to be used as a template for the symbols mentioned in the previous paragraph.

a. Istructions for Use of the Very Low Altitude Ruler

(1) Marking of the course on the chart. Past each turning point, the turn must be marked on the chart; the radius of turn is a function of the Mach Number.
The four curves on the ruler correspond to an indicated Mach number of 0.45, 0.55 and 0.50, 0.60. Reference marks along the curves are for every 10 seconds of flight.
The course to the next turning point is tangent to the curve.

NOTE

For right hand turns, reverse the ruler.

(2) Marking of flight time (graph no. 11 of fig. 11-38). Place the ruler above the marked course, as in instruction, so that the horizontal line corresponds to the desired Mach number. Interpolate for intermediate Mach numbers. Slide the ruler longitudinally so that the point at the end of the turn corresponds to the time (seconds) required to fly the turn, which is marked on the TIME scale. Insert the tip of the pencil in

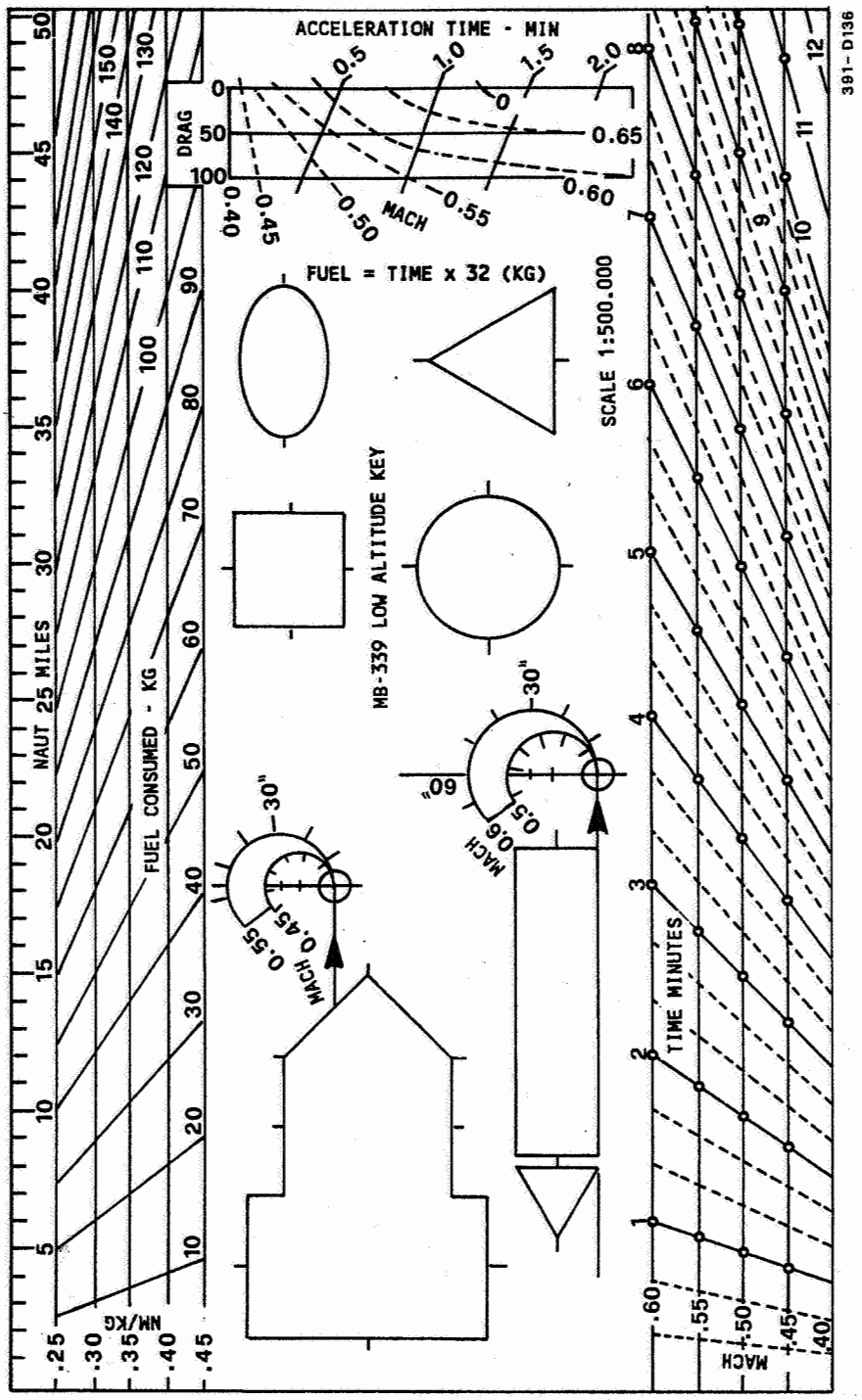


Figure 11-37. MB-339A Plotter - Low Altitude Key

1. NAUTICAL MILES SCALE FOR 1:500000 CHART
2. FUEL CONSUMED GRAPHS AT DIFFERENT SPECIFIC RANGES
3. WINDOW TO TRACE ON THE FOLDER THE ARROW BOX
4. WINDOW TO TRACE ON THE FOLDER THE INFORMATION BOX
5. WINDOWS TO TRACE ON THE FOLDER THE RADIUS OF TURN FOR DIFFERENT IMN
6. WINDOW TO TRACE ON THE FOLDER THE INITIAL POINT (IP)
7. WINDOW TO TRACE ON THE FOLDER THE RESCUE POINTS
8. WINDOW TO TRACE ON THE FOLDER THE TURNING POINTS
9. WINDOW TO TRACE ON THE FOLDER THE TARGET
10. TIMES AND SPACES TO ACCELERATE TO FINAL MACH NUMBER
11. ELAPSED TIME (MINUTES) GRAPH, FOR DIFFERENT IMN

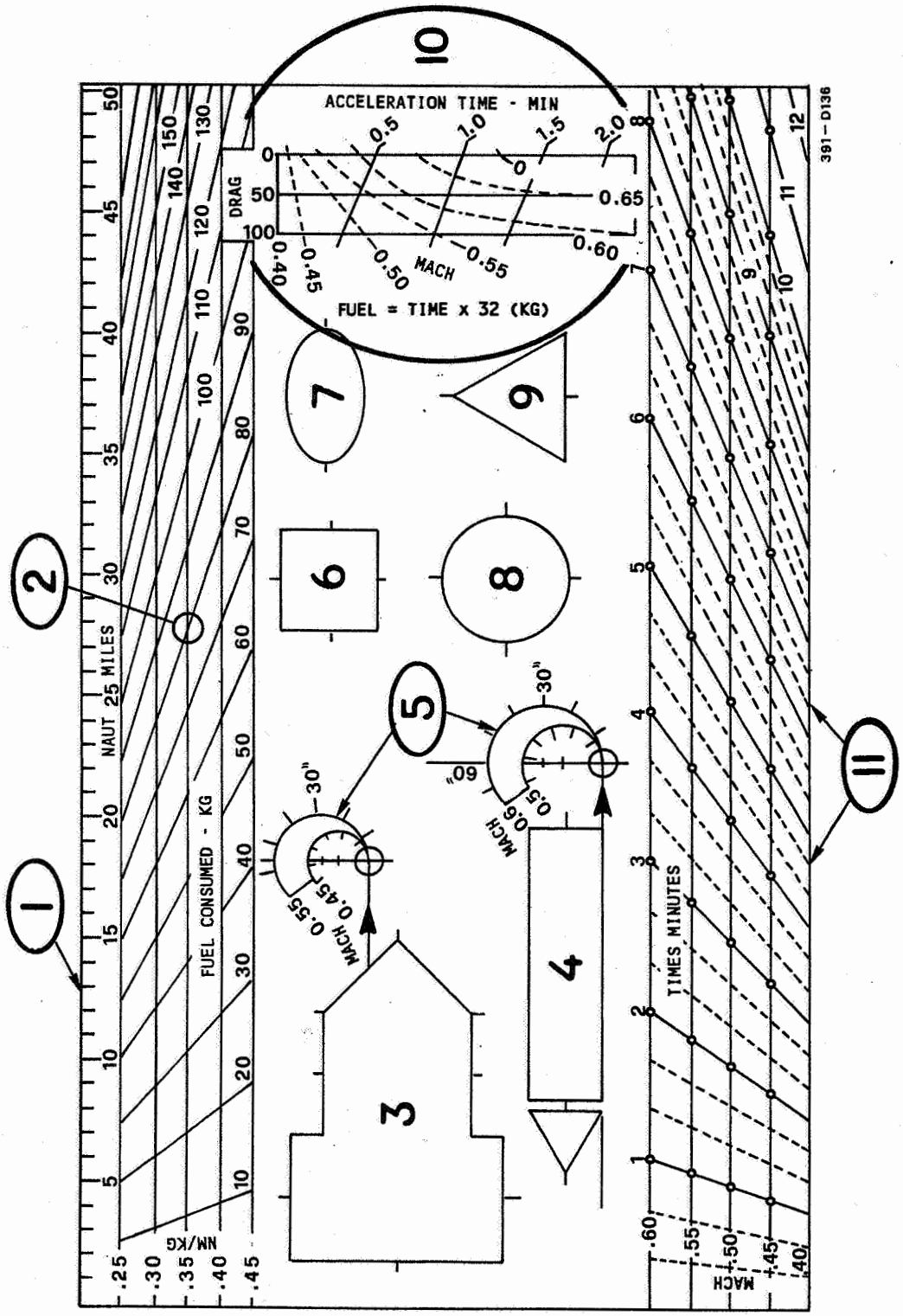


Figure 11-38. Plotter for Planning of Low and Very Low Altitude Aerotactical Missions

the tiny holes on the TIME scale and mark the time on the chart, minute after minute.
From the intial point (or another acceleration point, if prescribed), mark acceleration as follows; use graph 10.
Lay down the chart so that the longitudinal line corresponding to the drag index overlaps the course and the dashed line corresponding to the initial Mach number (cruise) coincides with the initial point.
At the final Mach No. read:

- On the chart (looking through), the point at which the final Mach number is attained

- On the chart, the time taken to attain the final Mach number.

The fuel consumption to accelerate (in kg) is got by multiplying the time in minutes needed to accelerate by 32.

(3) Marking on the chart the fuel consumed/fuel remaining data.

(a) Calculate the specific range (Nm/kg) at very low altitude, corresponding to Mach No., mass and drag index (see performance tables or graph of fig. 11-18 and 11-19).

(b) Place the ruler on the course line so that the horizontal line corresponding to range (NM/kg) calculated in (a) is on the course line (interpolate if required)

Read the quantity of consumed fuel, then write the remaining fuel estimated on the next turning point in the last section of the arrow box.

7. RADIO AIDED NAVIGATION

a. General

Radio aided navigation, as well as the MB-339A aircraft airborne radio navigation equipments are illustrated in detail in publication PI AD-03-39A "Instrument Flying and Navigation Manual".
This paragraph indicates only the information which is useful for the pilot to plan and carry out the navigation using the airbone radio navigation systems.
It is possible to navigate both in VMC and IMC, however, irrespective of the weather conditions, everytime the mission is flown according to the IFR, path and times will be referred to precise points on the ground which represent the overhead position of radio aids or vectors (bearing, distance) from known radio aids.

b. Airborne Equipments

The MB-339A aircraft in service with the IAF, can avail of the following radio aids:

- TACAN
- VOR
- RNAV and integrated HSI/ADI/Flight director system
- ILS

It carries provisions for the installation, on request, of:

- ADF
- VDF
- UDF

- The Radio Navigation System of other customers was made according to their Airforce Specification.

It can also obtain bearings and fixes from direction finding stations or radar stations on the ground through the UHF or VHF radio communication system.
The airborne IFF provides coded identification of the aircraft to the ground radar stations equipped with a secondary interrogating radar, that can thus locate the aircraft without possibility of error (FIX).
The procedures applicable to the navigation equipment and the relevant piloting techniques are illustrated in detail and with examples in the abovementioned publications.

c. Publications Useful for Radio Aided Navigation

Prior to proceeding to actual flight planning, it is necessary to review the special publications to get the complete set of data essential to carry out a correct and accurate planning.

(1) FLIP Flight Information Publication. This publication contains all data on airports, radio aids and air traffic control activities.
Among the most important data, there are:

- Characteristics of the destination runway (length, elevation, lighting, etc)
- Available starting equipment
- Available servicings (fuel, oxygen, oil)
- Type of barrier
- Radio frequency (TWR, APP, GCA)
- Radio aids (type, designation, frequency, location)
- GCA (frequencies, glide angle, path)
- ILS (frequencies, glide angle, path)
- En-route radar assistance (designation, frequencies, coverage areas).

(2) Navigation charts (fig. 11-39). The FLIP charts (high or low altitude) are generally used to make plotting easier.
All airways, with the relevant designations, magnetic heading, radio aids, minimum and maximum levels are listed in these charts. The boundaries and the elevation boundaries of the different CTR, TMA, FIR, ATZ, controlled, danger and prohibited areas are also indicated therein.
On these charts, the most significant radio aids are identified with their symbol and a compass card showing the magnetic headings. These cards are not aligned with the chart meridians, but are oriented toward the magnetic North.
As an aid, it is recommended to carry on board the 1:1 000 000 Operational Navigation Charts, in order to visually monitor the planned track when the meteo conditions permit it.

(3) Instrument approach charts. They are gathered in the Local National Approach Chart Booklet and/or the DOD-FLIP of the Defence Mapping Agency USA (fig. 11-40).

(4) Possible instrument departure charts of the main airports (SID = Standard Instrument Departures) (fig. 11-41).

(5) "Performance Data Manual" PI 1T-MB339A-1-1. The reading of the performance data tables permit all the data required for a correct planning of navigation to be obtained.

(6) Symbols on radio navigation charts. The radio navigation charts have a legend specifying all conventional symbols used in the chart, but the student pilots should already be familiar with them. It si remembe-

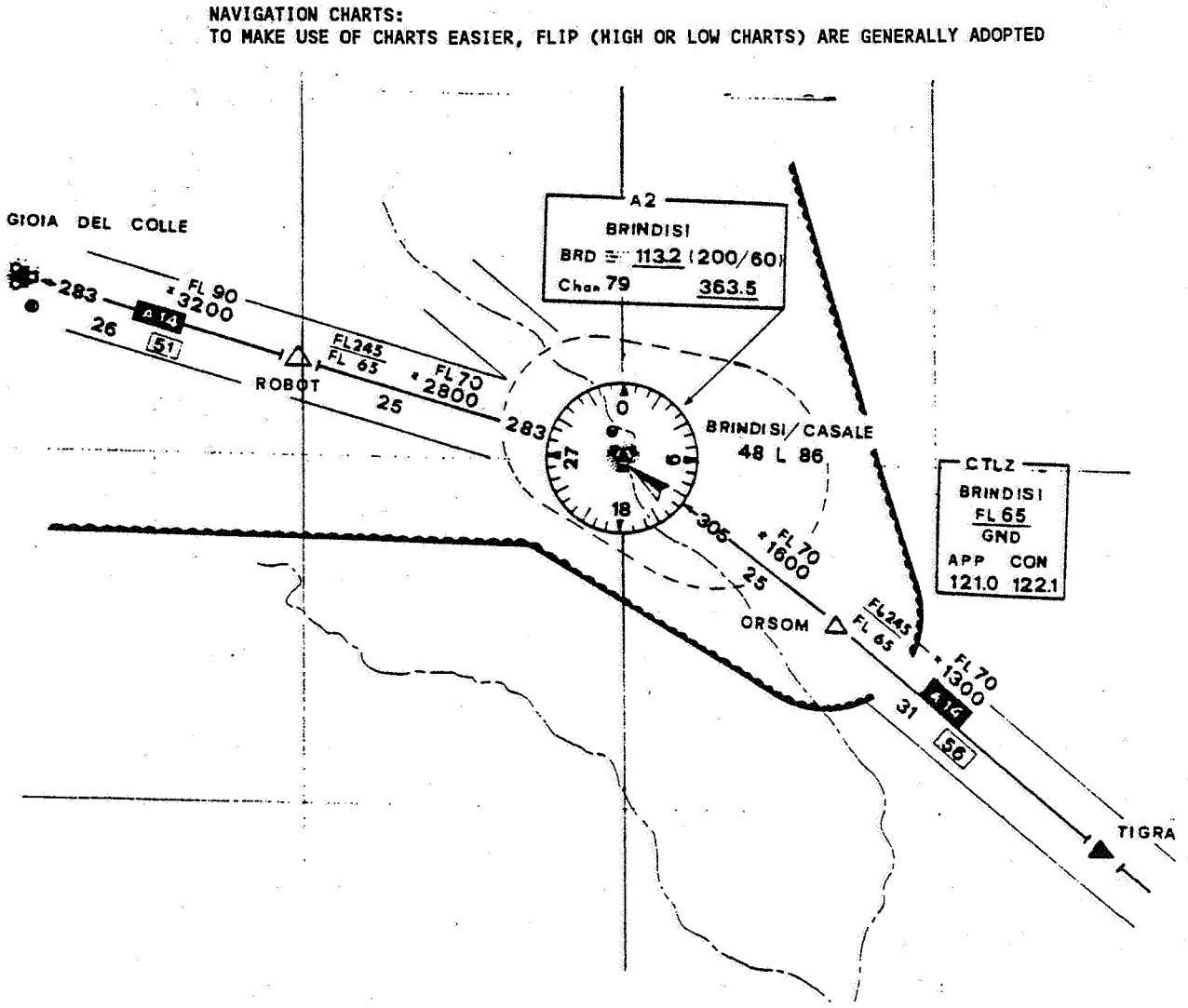
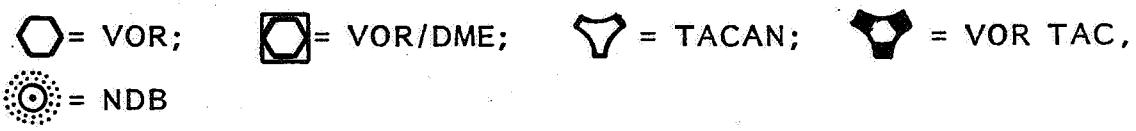


Figure 11-39. Radio Navigation Chart

red that the elevation of the mid point of the airport runways is given in feet (213 means 213 ft), the length of the longest runway is indicated in hundreds of feet (97 means 9700 feet). Therefore, Lecce 158-61 means: Lecce ITALY airport, elevation 158 ft, runway length 6100 ft. The miniature compass cards on the charts are oriented to the Magnetic North and are centered on the VOR and TACAN radio aids.
Symbols and their meaning:



▲ = Mandatory reporting point; △ = Non mandatory reporting point

(7) Radio aids available on the ground. The radio aids available on the ground are described in detail in the "Instrument Flying and Navigation Manual" PI AD-03-39A. A brief summary is however given hereafter:

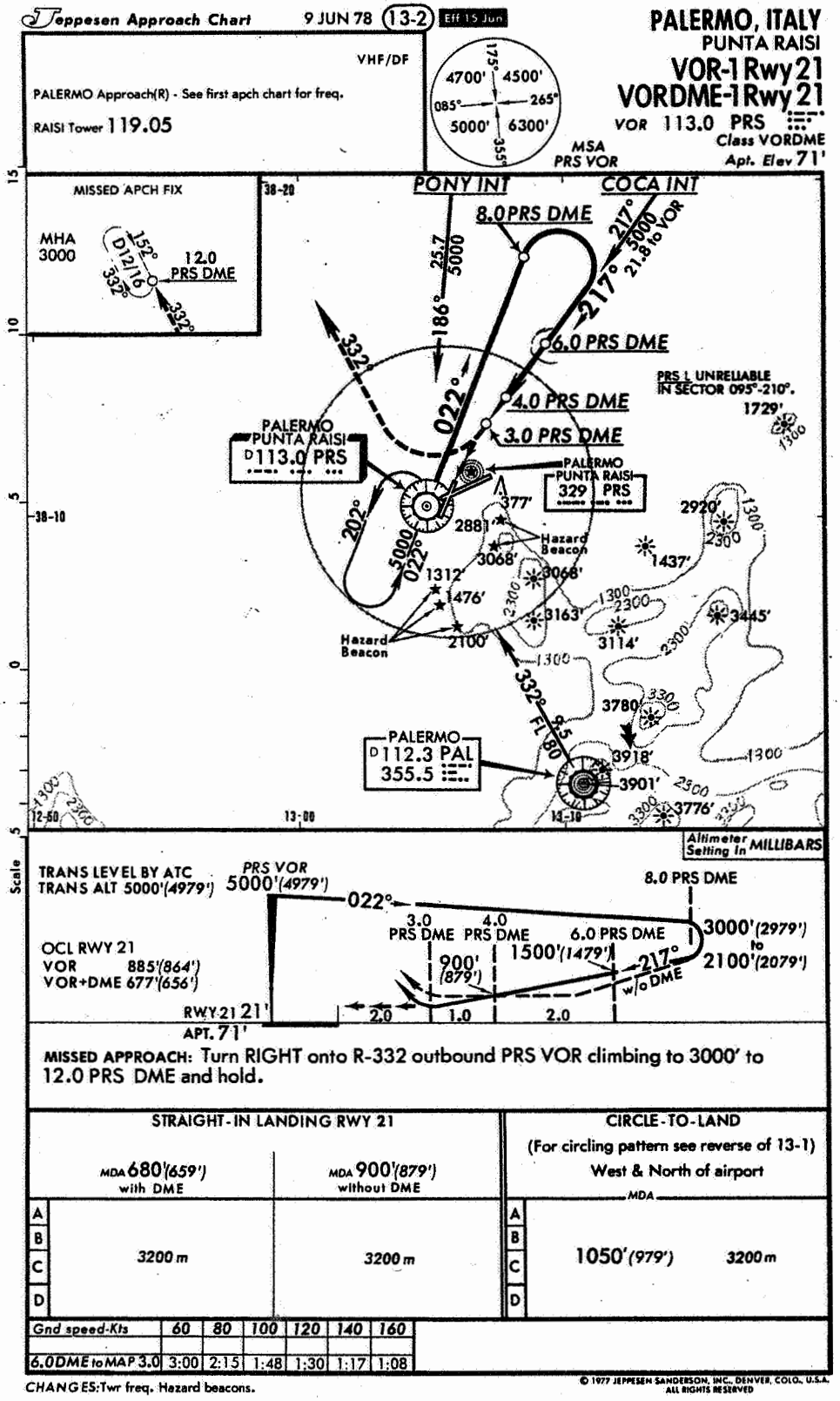


Figure 11-40. Instrument Approach Chart

(a) TACAN (Tactical Air Navigation). Short range navigation system (up to approx 200 NM from station) that operates in the frequency range of 1025 to 1150 MHz (SHF), and provides the pilot with azimuth information through the transmitter and with slant range information through the associated DME transponder. The station transmits its three letter identifier in Morse code every 35 seconds to afford identification. Reception of the tone signal without the Morse code identifier in-

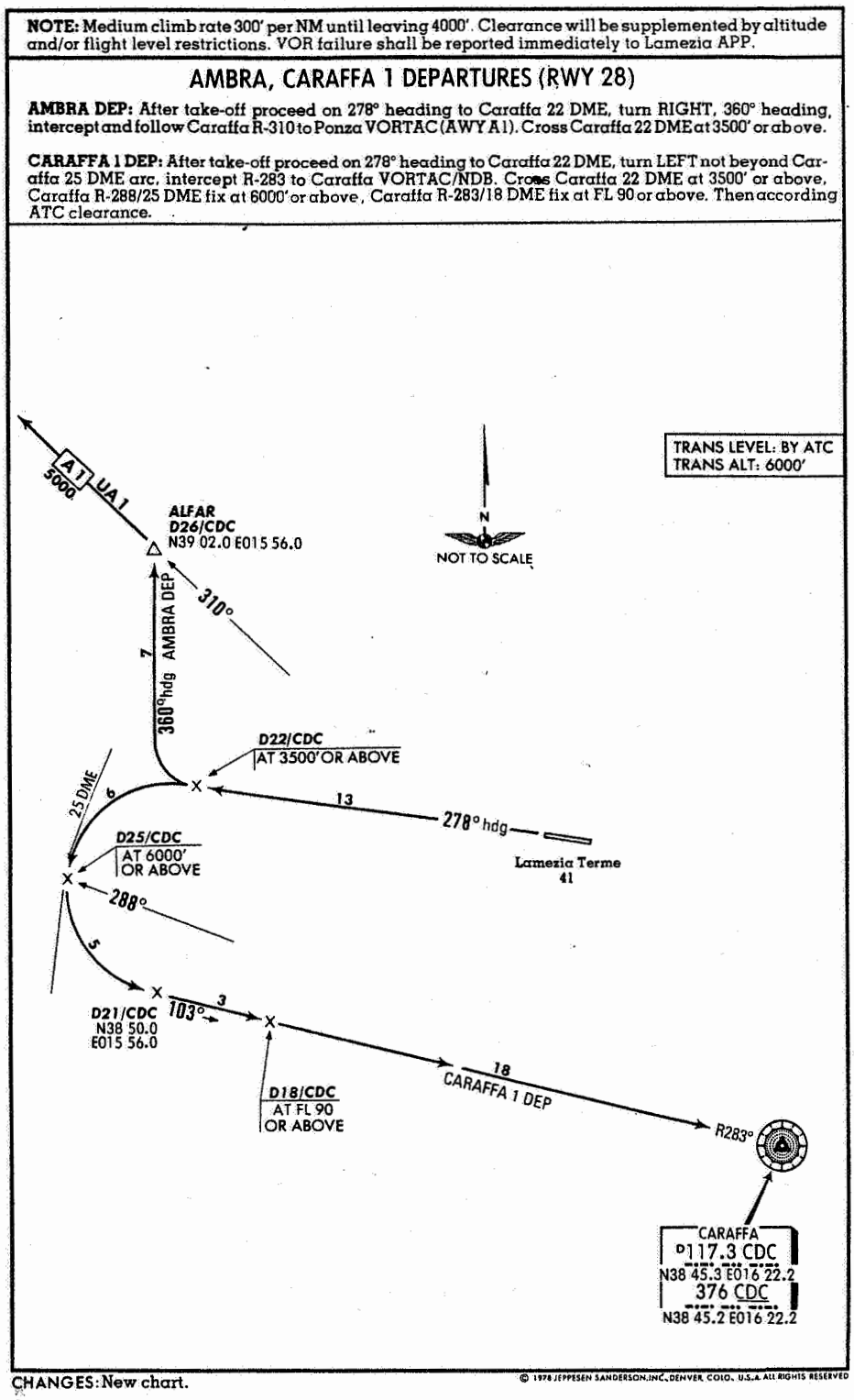

NOTE: Medium climb rate 300' per NM until leaving 4000'. Clearance will be supplemented by altitude and/or flight level restrictions. VOR failure shall be reported immediately to Lamezia APP.
AMBRA, CARAFFA 1 DEPARTURES (RWY 28)
AMBRA DEP: After take-off proceed on 278° heading to Caraffa 22 DME, turn RIGHT, 360° heading, intercept and follow Caraffa R-310 to Ponza VORTAC (AWY A1). Cross Caraffa 22 DME at 3500' or above.
CARAFFA 1 DEP: After take-off proceed on 278° heading to Caraffa 22 DME, turn LEFT not beyond Caraffa 25 DME arc, intercept R-283 to Caraffa VORTAC/NDB. Cross Caraffa 22 DME at 3500' or above, Caraffa R-288/25 DME fix at 6000' or above, Caraffa R-283/18 DME fix at FL 90 or above. Then according ATC clearance.
TRANS LEVEL: BY ATC
TRANS ALT: 6000'
A1
5000
UA1
ALFAR
D26/CDC
N39 02.0 E015 56.0
N
NOT TO SCALE
310°
7
AMBRA DEP
360°hdg
D22/CDC
AT 3500' OR ABOVE
25 DME
6
13
278° hdg
Lamezia Terme
41
D25/CDC
AT 6000'
OR ABOVE
288°
5
3
103°
D21/CDC
N38 50.0
E015 56.0
D18/CDC
AT FL 90
OR ABOVE
18
CARAFFA 1 DEP
R283°
CARAFFA
D117.3 CDC
N38 45.3 E016 22.2
376 CDC
N38 45.2 E016 22.2
CHANGES: New chart.
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Figure 11-41. Instrument Departure Chart

forms the pilot that the TACAN ground station is being calibrated, inspected or is unreliable.

(b) VOR (VHF Omnidirectional Range). Short range navigation system that operates in the frequency range from 108.000 to 117.95 MHz, and provides the pilot with azimuth information. The identification signal

of three letters in Morse code is made audible by the different modulation of the phase and the reference signals. In case of lack of transmission of one or both signals, the VOR receiver remains silent. The VOR will conversely transmit the audible tone at 1020 MHz, but not the morse identifier when the station is undergoing maintenance, checks, calibration, etc. and bearing correctedness is not guaranteed.
A DME station is usually located in the immediate proximity of a VOR station. It is identical to the TACAN station and operates in SHF with a frequency associated to the VOR frequency. A VOR/DME station is thus available.

(c) VORTAC. A VOR and TACAN station located at a few meter distance from each other and having the same identifier and associated frequencies.

NOTE

See "Instrument Flying and Navigation Manual", PI AD-03--39A.

(d) ILS unidirectional beacons. The ILS (Instrument Landing System) is a precision approach system providing information of direction (LOCALIZER associated with a transmitter operating in the VHF band), and of glide path (GLIDESLOPE associated with a transmitter operating in the UHF band).
The ILS localizer transmitter repeatedly transmits a group of four letters in Morse code. The first letter is always an I to indicate the ILS radio aid.
A G/S frequency is associated to each LOC frequency.
The airborne equipment automatically changes the G/S frequency as a function of the selected LOC frequency.
The LOC frequency of the ILS is in the range from 108.1 to 111.9 MHz (odd decimals only).
The not yet operative ILS stations transmit the tone without the identifier code.
A positive identification of the selected station prevents doubts from arising as to tuning or satisfactory operation of the airborne equipment or the ground transmitting station which would result in errors, and even serious errors, during the final approach phase.
The graphic symbol of the ILS is :

(e) Ground directional finder stations - UDF and VDF (shortening of acronyms UHF/DF and VHF/DF). They are installed nearly on all military and civil airports. Additionally some navigation UDF and VDF are still available. They provide QDM/QDR/QTE with respect to their location.

d. Flight Planning

To plan a flight means to carefully look for and find all data necessary to navigate from an airport to another, and to enter these data in a special flight log according to a logical sequence.
To do this, it is necessary to have available all the required material (rulers, goniometer, plotter, etc.), as well as the already mentioned publications.

(1) General. If a ferry flight is to be flown from an air base to another, or a out and return flight, it is usually required that a route be chosen on which the checkpoint are TACAN, VOR, VOR/DME, VOR/TAC stations. When checkpoints must be overflown that house stations that cannot be exploited by the airborne equipments (ex. NDB if the aircraft has no ADF installed), it is advisable to identify

their position with respect to a TACAN, VOR/DME or to the RNAV. Position will then be established either by bearing and distance from a radio aid or by recalling the stored data of that waypoint.

(2) Average latitude - average variation. First of all, reading the charts is useful to indicate the value of the average latitude of navigation to permit entry of this data through the "AHRS" control panel during the pre-start checks. Magnetic variation (which is already calculated in the airway charts) will be used to determine magnetic headings.

(3) Take-off data. These data are obtained from the performance charts and refer to the take-off run, go-no go speed, refusal speed.

(4) Climb data. Climb will be carried out by looking at the performance tables as a function of the aircraft drag index. It is therefore necessary to calculate the time, distance and fuel required to accelerate to the required speed from the time of brake release. Subtracting the weight of the fuel consumed on the ground and that of the fuel required to reach the acceleration point from the aircraft gross weight, it is possible to obtain the aircraft weight at the start of climb.
For the MB-339A aircraft in clean and ferry configurations, the standard take-off data that can practically apply to all conditions are as follows:

AIRCRAFT		CLEAN	FERRY
Total mass at parking	Kg	4400	5020
Fuel consumed for ground run, take-off, acceleration	Kg	80	80
Available fuel after acceleration	Kg	988	1479
Aircraft mass at start of climb	Kg	4320	4940
Take-off distance (OAT = + 25°C)	m	520	660
Distance over obstacle (OAT = + 25 °C)	m	800	1040

Calculate climb data up to cruise altitude (time, distance and fuel consumed)

(5) Flight levels (fig. 11-42). The flight levels are chosen by complying with the flight rules and taking into account the optimal cruise level obtained from the "Performance Data Manual".
In theory, to optimize fuel consumption, the flight level should be changed progressively as the aircraft mass changes, but this is not done in reality in view of the problems that it would cause to the air traffic control activities; therefore, the optimal cruise level is determined as a function of the distance to travel and of the aircraft mass at the end of climb; it must also be in compliance with the semi-circular level rule.
The minimum IFR level in the airways is shown on the radio navigation charts. Outside the airways, the minimum IFR cruise level must be at least 1000 ft above the highest obstacle in a strip of 10 NM on both sides of the route and extending 10 NM beyond the turning point (fig. 11-43).

(6) Cruise data. If cruise level and navigation distance are known, the indicated airspeed or Mach number will be chosen, that is optimal for that navigation.
It is known that at altitudes of about 20 000 ft, the Mach number multiplied by 10 approximatively corresponds to the miles travelled in one minute. This will remarkably simplify the calculations in flight.
For instance, dividing the length of each navigation leg by the NM per minute yields the flight time on each leg.

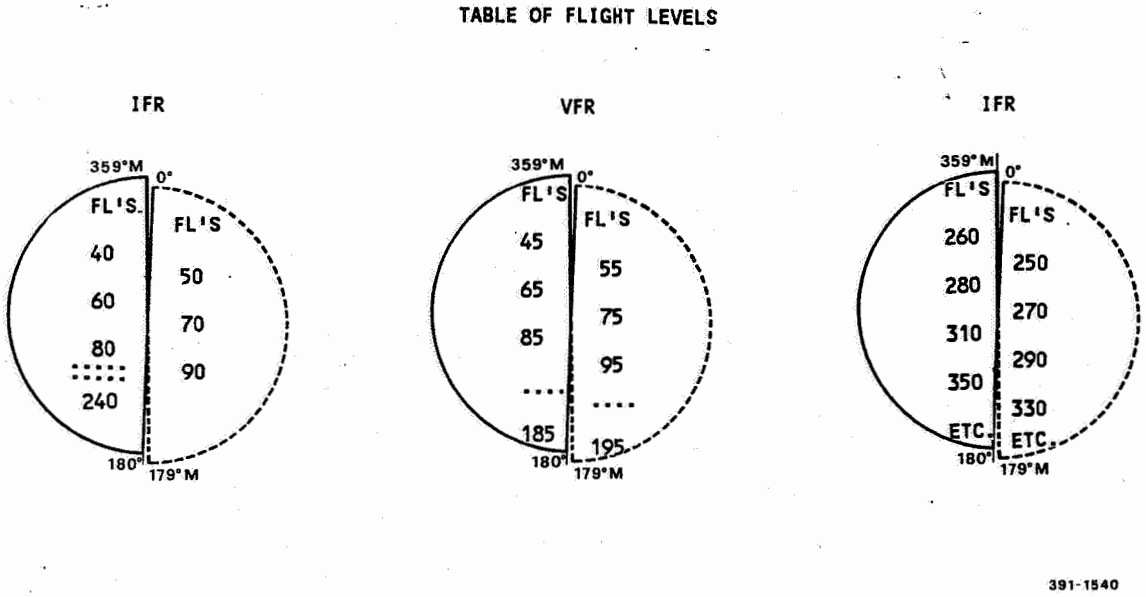


Figure 11-42. Semi-circular Levels.

In the same way, if time is multiplied by the consumption rate read on the flowmeter, consumption on each leg is got.

(7) Heading. Magnetic headings are obtained from the FLIP charts (high or low). Usually these charts also indicate the airway heading. To head to one or more points out of an airway, it is possible to determine the relevant course either during flight planning or (with sufficent accuracy) in flight by placing the edge of a sheet parallel to the heading to be determined and passing through the center of the closest compass card printed on the map.

(8) Distances. The distance between the different checkpoints, when not indicated on the chart, can be determined during flight planning on the ground or calculated in flight with sufficient approximation by measuring the segment that joins the considered points and comparing this segment to the scale in miles placed at the bottom of the chart or measuring along a meridian (1 NM = 1 minute).

(9) Descent data. Data and configurations applicable to descent must be calculated by reading the special tables, as a function of the residual fuel, drag index, and type of descent that it is intended to fly. The time usually required to fly a standard penetration descent is approx. 10 minutes.

(10) Data to reach the alternate airport. It is always essential to plan a diversion to one or more alternate airports located along the route and in proximity of the destination airport. This need arises from the possibility of incurring in an in-flight emergency, of meeting adverse weather conditions enroute, or of finding that the runway of the destination airport is unlandable.
In compliance with the criteria set forth above, determine course, distance, time and fuel required to reach the alternate base.
In order to optimize the fuel consumption, it is essential that the optimal level for diversion to the alternate both at low and high altitude be established.

(11) Data applicable to the no-return point. The no-return point is the point (along the route) past which it is impossible to return to the home base. This point, in flight time, is calculated by solving the following equation with the aid of the plotter:

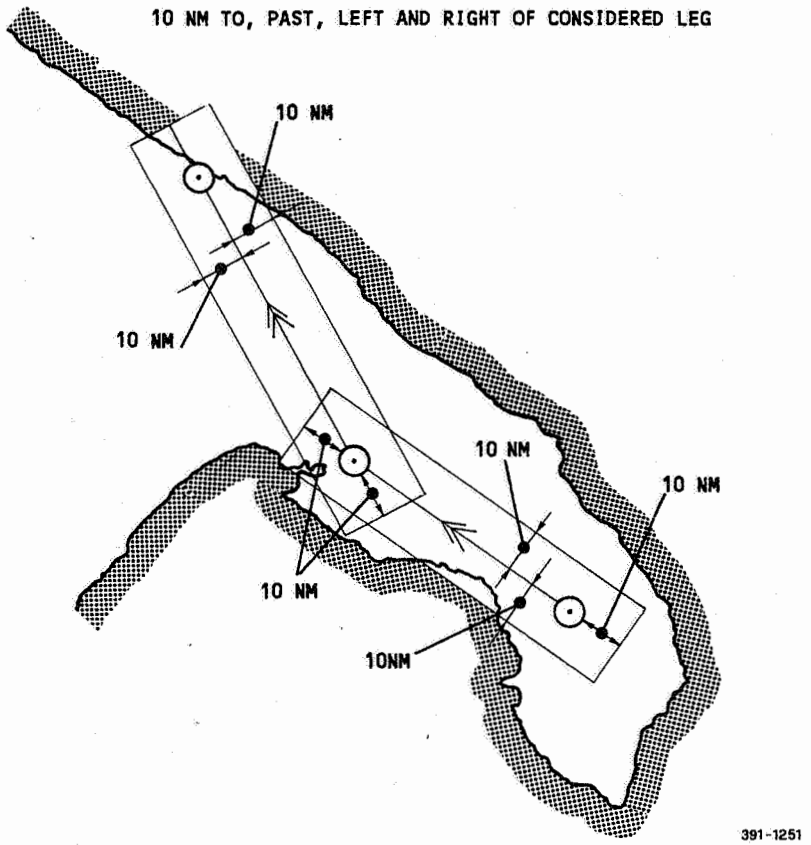


Figure 11-43. IFR Safety Band

$$\frac{Gsr + Gso}{Gsr} = \frac{T}{to} \qquad to = \frac{Gso \times T}{Gsr + Gso}$$

Gsr = Ground speed, inbound (return)

Gso = Ground speed, outbound

T = Fuel quantity expressed in flight hours

to = Outbound time after which it is impossible to return to home base

(12) Radio aids and frequencies. It is necessary to note all V/UHF frequencies that will presumably be used during navigation: besides, it is useful to note all radio aids that could be exploited during the navigation. As far as these aids are concerned, the following data will be noted: TACAN channel, VOR frequency (or both), and the Morse code identifier to remove any doubts as to the station identification.

(13) Flight log. It is a special form on which all previously acquired data are entered and represents the flight schedule to be adhered to during navigation.

e. Preparing the Flight Plan

Before filling in the flight plan, contact the weather station to know the meteo situation along the route in general and the present conditions (METAR) and forecast conditions (TAF) on the destination and alternate airports.

Navigation will be accomplished if meteo conditions exist on the destination airport, which permit an approach procedure to be flown in compliance with the minimums applicable on that airport as read in the, Approach Procedures FLIP and depending on the usable radio aids. These meteorological conditions should not be expected to undergo substantial changes (TAF) for at least 2 hours.
As far as the choice of the alternate airport is concerned, it must be made basing on the distance and the weather conditions, which are to meet the applicable minimum requirements.
A special importance for the en-route meteo conditions, is borne by the information provided by some radar echoes, that indicate the presence of thunderstorm clouds that have to be avoided as they are extremely dangerous.
Once the meteo situation is known, and before filling in the flight plan, the pilot should contact the ARO to obtain additional information.

(1) He should note the conditions of the radio aids on the departure airport, on the destination airport, on the alternate airport and along the route.

(2) He should take note of possible temporary or permanent airspace restrictions.

(3) He should read the notams referring to the destination airport and alternate airports: they include useful information such as: landing possibility, fuel, oxygen availability, parking areas, assistance, construction works in progress, serviceability of the radio aids, possible changes of frequency, etc.

NOTE

Some airports require that a permission to land be obtained from the concerned Operation Offices 24 hours before the expected landing. Therefore, in order to avoid unpleasant landing refusals, request the permission in due time (PPR = Prior Permission Required), and enter in box 18 of the flight plan, indentifying it with a number.

(4) Finally prepare a flight plan by using the special, already illustrated forms.
The flight plan must be handed over at least 30 minutes before the estimated time of departure (ETD) in case of IFR flight plans, and 15 minutes before that time in the case of VFR flights.
The choice of the type of flight plan will be made as a function of the meteo conditions on the departure airport, on the destination airport, the conditions of the different radio aids, the selected flight level, and the applicable training requirements.

NOTE

Occasionally it might be useful to use a Z type flight plan (departure in VFR and change to IFR at a pre-established point and altitude), or a Y type flight plan (start in IFR, subsequent deletion of the flight plan and continuation in VFR). It is remembered that the above cancellation is possible at flight level 195 or lower, provided VMC exist.

f. Before Take-off Operations

(1) It is remembered again that the maximum attention must be paid during the pre-start check, to have the latitude value entered in the AHRS through the LAT knob, this latitude should correspond to the mid-latitude of the course.

In IFR navigation with Y or I type flight plans, once checks have been completed, clearance to start up must be requested to the tower before starting the engine.

(2) The following operations must be carried out during the pre-taxi and pre-line up checks:

- TACAN-VOR/ILS-IFF-RNAV: self test

- RNAV: if not yet stored, enter the waypoints that were previously established and written on the special log according to the known procedure, in the CDU.

(3) Clearance from the Air Traffic Control activity. If the flight plan involves an IFR departure (flight plan type I or Y), during taxi the pilot must write down the clearance obtained from the concerned ACC and repeat this clearance to the tower on the correct frequency. When the clearance is correctly read back, the flight plan can be considered accepted.

NOTE

If it is believed that the received clearance may adversely affect the safety of flight, in particular as far as detours from course are concerned, or because flight levels are assigned that result in an excessive fuel consumption, the pilot may refuse the clearance. In this case he must call the tower and coordinate his action with it to obtain a new clearance. This amended clearance should reflect the previously submitted flight plan as far as possible. If this action does not yield satisfactory results, the pilots asks to return to the parking area.

g. Take-off and Instrument Departure

After take-off proceed in accordance with standard instrument departure (SID) specified in the clearance.
During this phase, slave the TACAN or VOR function to the HSI, depending upon the used radio aid.
In case of malfunction of the ground equipment, suitably use the RNAV in order to correctly complete the instrument departure. After completing this procedure and reaching the cleared cruise level and the planned airspeed, head to the first chekpoint using the TACAN or the VOR/DME and, if required, the RNAV, as an aid.

h. Cruise

- After stabilizing with the correct parameters at the final cleared level and receiving confirmation from the ATC activity, proceed with navigation according to planned course, altitude, airspeed, estimated positions, checkpoints and carrying out all radio calls in conformance with the envisaged standard.

- Suitably exploit all available radio aids (TACAN-VOR/DME-RNAV), but remember that the indications of the TACAN and VOR are always to be preferred to those of the RNAV, especially when flying in IMC. The latter equipment in fact is less reliable because of possible errors resulting for instance from an incorrect entry of the data, computer malfunction, etc.

- When the checkpoints are overflown that are not locations provided with TACAN or VOR/DME stations, obtain the FIXES by enforcing the procedures already learned for the radio-aided navigation instrument flying.

- Conversely, when TACAN or VOR/DME stations are overflown, it should be remembered that bearing information are missing in the confusion cone. Therefore, when approaching the station, and a fairly large turn must be flown to the new heading (fig. 11-44), apply the envisaged distance lead (already dealt with in radio aided instrument flying section), to avoid overflying the radio aid and needing to return on course with the ensuing unavoidable greater fuel consumption and longer flight path.

- Particularly when very long navigation legs are to be flown (checkpoints particularly far apart), once a position overhead the station is reached and the new heading set, use this radio aid to carry out all envisaged returns on course also when flying outbound. At a second time only, as soon as within the range of the new radio station, tune the set to the new frequency and head to the envisaged checkpoint, carrying out the required corrections to get back on course when approaching the station.

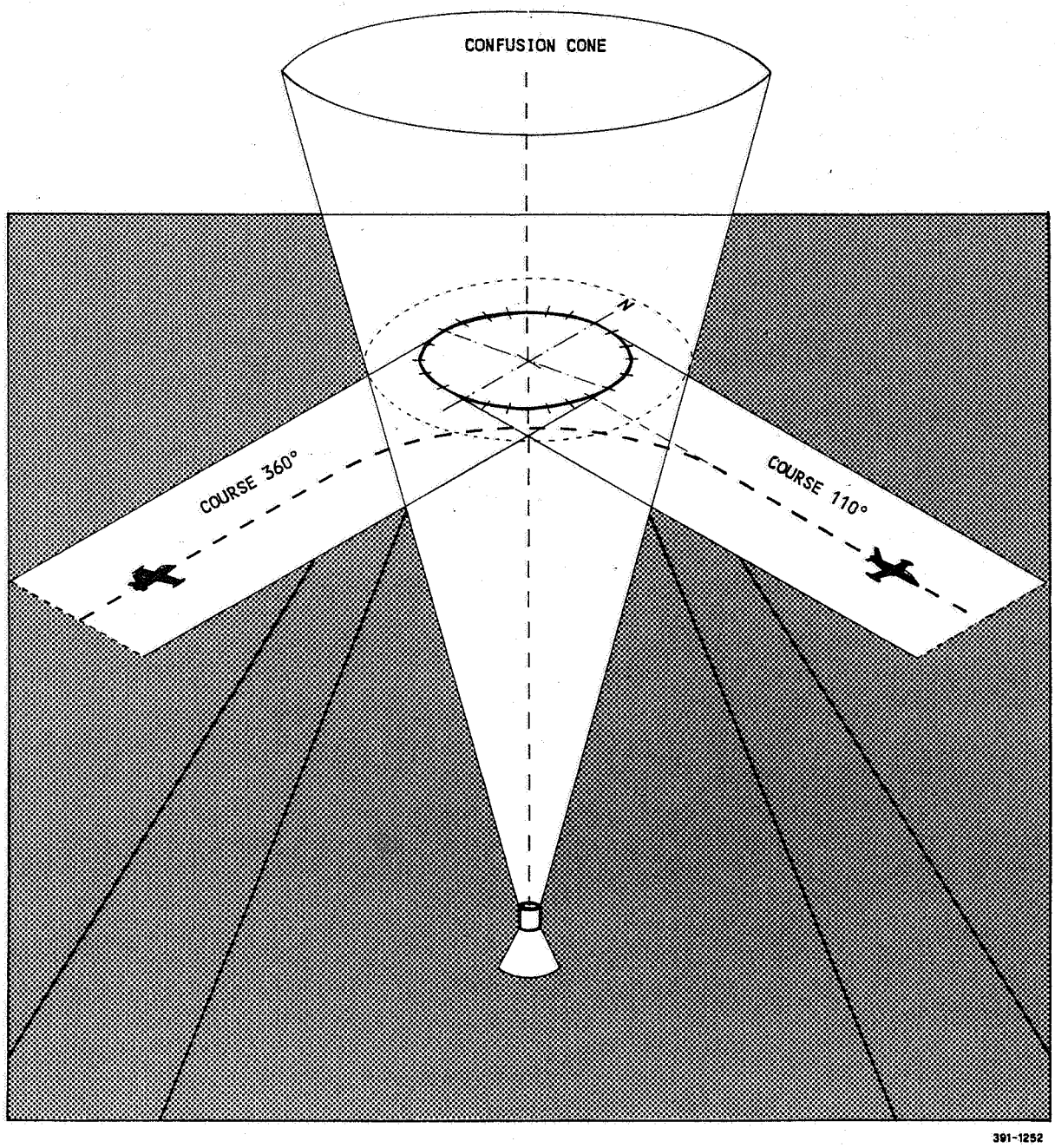


Figure 11-44. Turn Over TACAN Station

i. Wind Effects

During navigation, it may occur that the forecast wind (indicated by the weather station before take-off) is different, and occasionally significantly, from the wind actually encountered at the flight altitude. To fly the planned course it is therefore necessary to carry out a new drift correction.
The RNAV system facilitates this task because in the WIND function, it is capable of providing the data applicable to an average wind and of updating the wind data every three minutes.
During the possible returns on course it is advisable to fly shallow turns to intercept the course without lengthening the path and increasing fuel consumption.

j. Penetration

To carry out penetration, be it TACAN or VOR, comply with the procedures published in the PIV or follow the radar instruction in the case of the GCI.
It is advisable to consider the possibility of carrying out penetration with the aid of the RNAV (in VMC only) if normal radio aids are not usable.

k. Diversion to the Alternate Airport

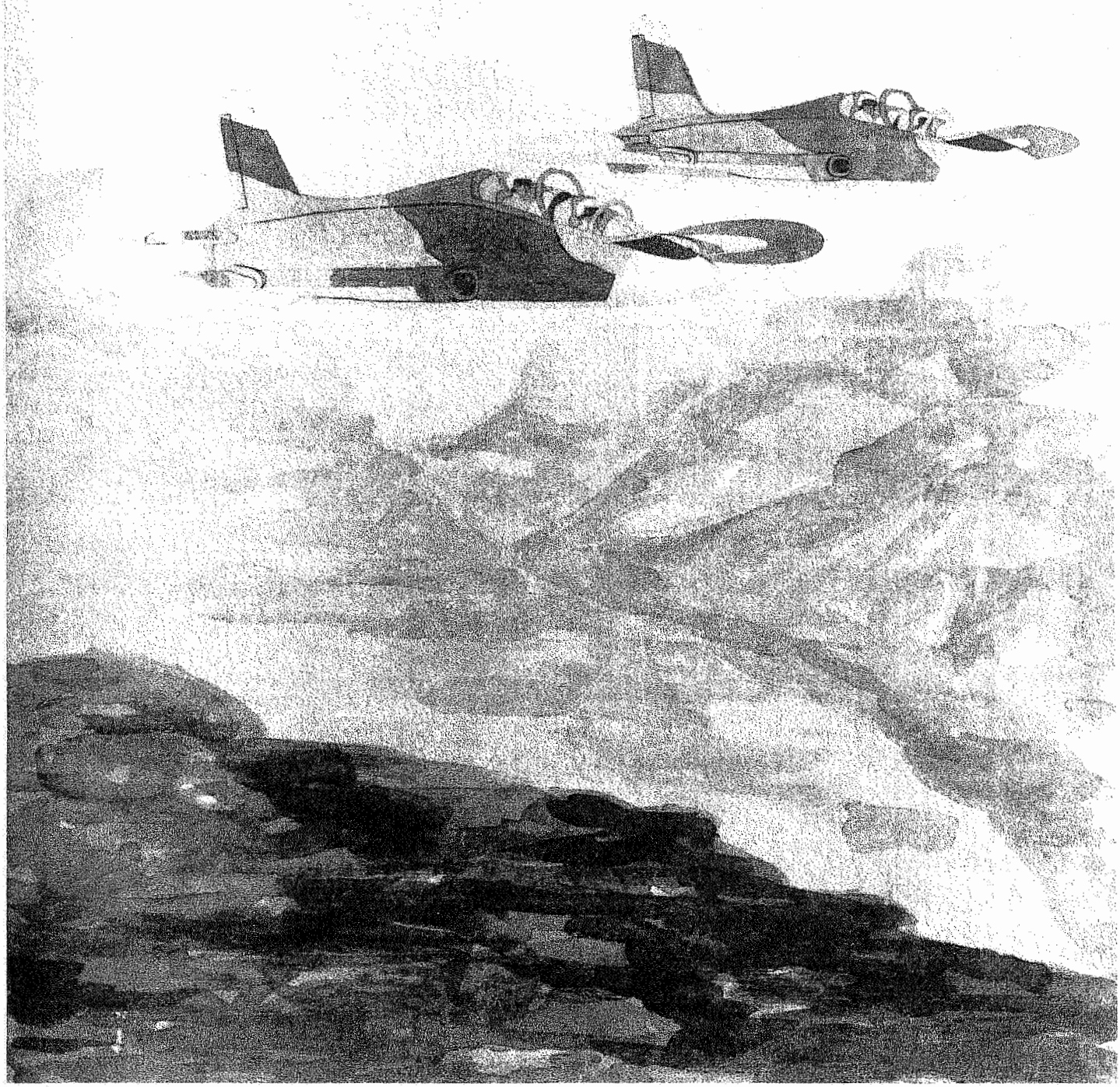
In case this occurrence takes place, immediately select the TACAN channel or the VOR frequency of the concerned airport, or recall the suitable waypoint.
As already specified, it is essential to attain the optimal flight parameters as soon as possible.
It is advisable to immediately coordinate the actions with the Air Traffic Control activities and keep them alert in case of any the occurrences.

NOTE

If it is believed that the alternate airport be reached in a fuel low condition, it is mandatory to timely advise the Air Traffic Control activities of this fact to obtain landing priority.

PART FOUR

OPERATIONAL TRAINING



PART FOUR - CHAPTER XII

FORMATION FLYING

TABLE OF CONTENTS

Title	Page
Introduction	12-1
General	12-1
Two-Ship or "Element" Fingertip Formation Flying - Pre-Flight Operations	12-9
Two-Ship Fingertip Formation Flying - Flight Conduct	12-12
Four-Ship or Larger Formations	12-29
Tactical Formation	12-44

1. INTRODUCTION

The preparation of a military pilot must necessarily include training in that peculiar activity in the air that is formation flying. The aim, which is essentially of operational nature, finds its ultimate reason in "mass" flying, that assures a concentration of fire, possibility of reciprocal defence and above all unified direction and command when several air units are flying together.
It is therefore necessary that during his training, the pilot be thaught the correct position in formation flying, starting with the basic two--ship formation which remains the essential element of all subsequent formations.
Formation, more than any other type of flying, provides the best environment for building confidence, teaching self-reliance, self-discipline and the proper application of aggressiveness in military flying.
All operational missions of the fighter pilots will be flown in formation.
Although training concentrates on techniques and procedures for the wing position, the student pilot will also be required to perform the responsibilities and duties as the leader.

2. GENERAL

a. Purpose

The following paragraphs aim at illustrating the basic notions required to carry out the maneuvers envisaged for TWO-SHIP and FLIGHT formations according to the standard procedures.

b. Collision Avoidance

To accomplish the objectives of the training course and maximize safety, it is essential that instructors and student pilots scrupulously stick to the collision avoidance procedures.
All pilots are required to take whatever action is deemed necessary to avoid mid-airs.

(1) All pilots in the formation must continually clear to the maximum possible extent.

(2) The wingman must above all devote his attention to maintain position with respect to the leader. This however does not mean that he cannot help clear for the formation. While referencing to the lead, the wingman may clear the area he sees beyond the leader.

(3) The leader must not concentrate so much on maneuver to compromise safety

c. Radio Procedures

The Flight Operations Office will assign a "call sign" (ex. "ALPHA"), to each formation.
The pilots in the formation will therefore have the following call signs:

- ALPHA ONE (or ALPHA LEADER)
- ALPHA TWO
- ALPHA THREE, etc.

In order to avoid misunderstandings, the leader is requested to call the call sign before any direction (ex. Alpha, speedbrake out .. now!).
All radio communications should be sharp, clear, and concise.
The following procedures apply to all formations:

(1) Change radio channel only prior direction from the leader and only after all pilots in the formation have acknowledged.

(2) When the flight leader directs a radio channel change, acknowledge and position unless in IMC and assume a "route" position.

NOTE

Route position is 1 ship apart and 5 meters behind.

(3) After the last wingman had checked in, (the shortest but clear acknowlegement is the formation number: i.e. TWO), return to the fingertip formation

(4) When flying in two-ship and convenient, change of radio channel may be directed visually.

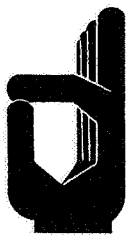
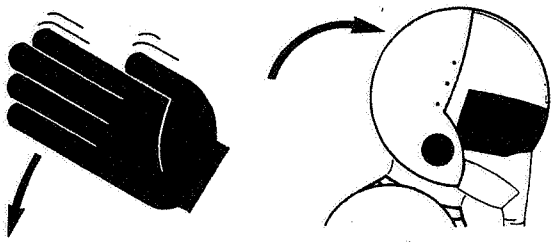
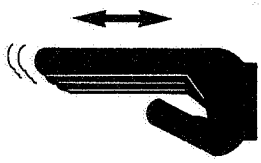
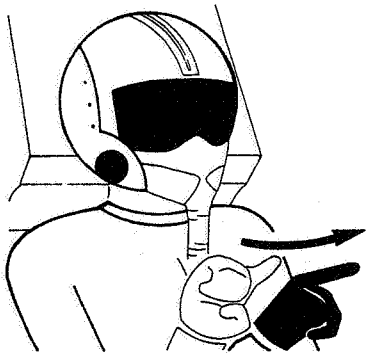
(5) All radio communications with the ATC must be carried out by the leader.

(6) The leader will direct a maneuver by calling and shortly pausing before the executive command (ex. ALPHA, speedbrake down ... now).
The radio procedures to be used during flight are included in the description of the different training phases.

(7) The wingmen must acknoledge leader's directions, except those regarding piloting (ex. reduce power to 78% RPM).
Wingmen's acknowledgment should be as short as possible (ex. Alpha two, Alpha three, Alpha four). In these cases however it would be advisable use "Wilco" (I WILL COMPLY). The simple formation number should thus be used only to acknowledge an instruction that has already been accomplished (ex. ALPHA TWO to indicate that radio channel has already been changed).

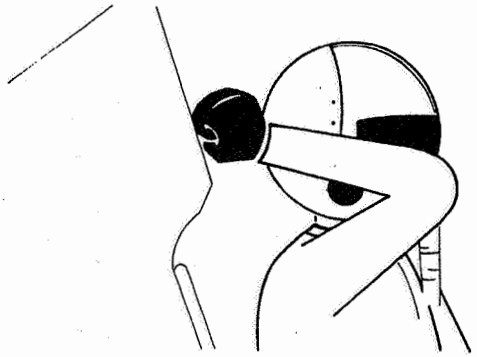
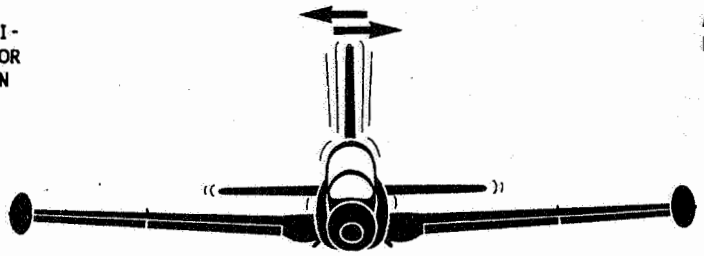
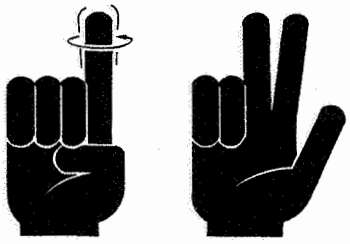
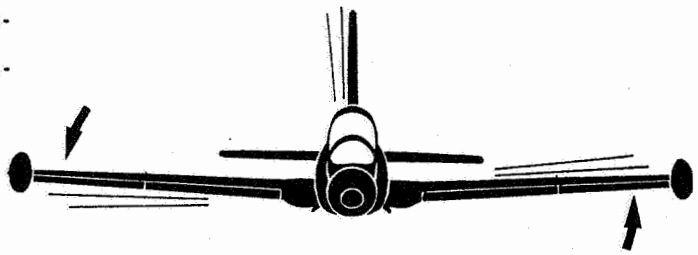
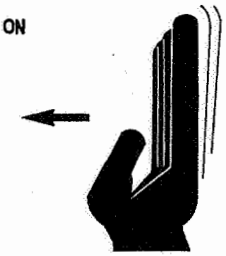
d. Standard Visual Signals (fig. 12-1)

Visual signals to be used in formation are precise and standard. They are usually employed to avoid saturating the radio frequency in use. Sometimes they are used for specific requirements (need to maintain radio silence, radio failure, etc.).

ENGINE TEST (EXECUTIVE SIGNAL) USED ALSO TO INDICATE START THE ENGINES		WITH FOREFINGER POINTING UPWARD, MAKE REPEATED ROTATORY MOVEMENTS
OK? IT IS USED ALSO TO INDICATE: I HAVE CHECKED AND EVERYTHING IS ALL RIGHT BOTH ON THE GROUND AND IN FLIGHT		MAKE AN "O" WITH FOREFINGER AND THUMB, OR NOD
RELEASE BRAKES (EXECUTIVE SIGNAL)		MOVE HAND WITH PALM VERTICAL FROM UP TO DOWN WHILE ROTATING THE FOREARM WITH RESPECT TO ELBOW. OR AFTER KNOCKING THE HAND ON THE HELMET, DO NOD
LEVEL OFF (EXECUTIVE SIGNAL)		MOVE HAND BACK AND FORTH KEEPING IT HORIZONTAL WITH PALM DOWN
CHANGE FROM ONE WING TO THE OTHER		POINT FOREFINGER TO THE WINGMAN, THEN INDICATE THE NEW POSITION. NOTE: THE SAME MANEUVER IS INDICATED BY DIPPING A LITTLE BUT FAST, THE WING ON THE SIDE OF THE DESIRED POSITION

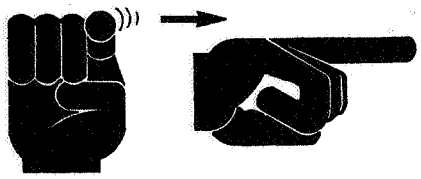
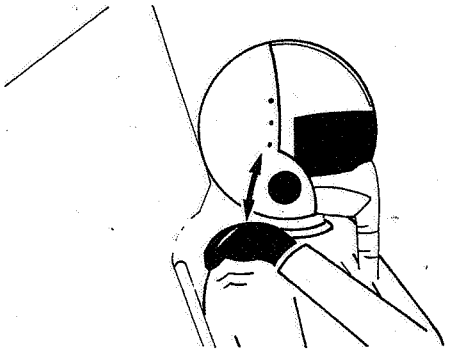
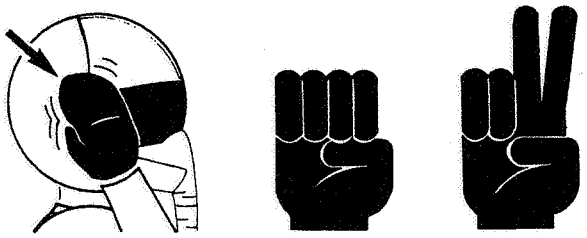
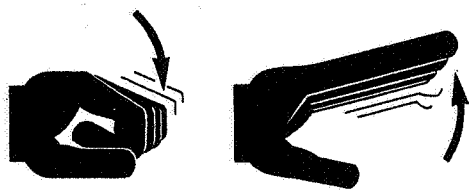
391-1253

Figure 12-1. Normal Visual Signals (Sheet 1 of 4)

CHANGE TO TRAIL FORMATION (EXECUTIVE SIGNAL)		BRING THE FIST TO THE NAPE OF THE NECK
CHANGE TO TACTICAL FORMATION OR WIDEN FORMATION (EXECUTIVE SIGNAL)		ALTERNATE DEFLECTIONS OF RUDDER
BREAK FOR SEPARATION FOR TRAIL OR LANDING (ADVISORY SIGNAL)		CARRY OUT A MOVEMENT LIKE THE ONE USED FOR ENGINE TEST, THEN KEEP FINGER STRETCHED OUT (1, 2 OR 3) ACCORDING TO DESIRED SEPARATION TIME (1 SEC., 2 SEC. OR 3 SEC.). THE START OF MANEUVER PERFORMANCE CORRESPONDS TO BREAK OF THE LEADER
RETURN TO WINGTIP FORMATION FROM TRAIL FORMATION (EXECUTIVE SIGNAL)		ROCK WINGS THREE TIMES; START A TURN ON THE SIDE (RIGHT OR LEFT SIDE) ON WHICH JOIN UP AND NEW FORMATION ARE REQUIRED. FIRST WING ROLL IS ON THE SIDE ON WHICH JOIN UP IS REQUIRED
CORRECT POSITION (EXECUTIVE SIGNAL)		MOVE PALM OF HAND IN THE DIRECTION OF DESIRED CORRECTION (PALM FORWARD: MOVE FURTHER FORWARD PALM AFT: MOVE FURTHER AFT, PALM TOWARD THE WINGMAN: MOVE FURTHER APART)

391-1254

Figure 12-1. Normal Visual Signals (Sheet 2 of 4)

CHANGE OF LEADER (EXECUTIVE SIGNAL)		POINT FOREFINGER TO THE WINGMAN WHO IS TO TAKE OVER THE LEAD, THEN POINT FOREFINGER FORWARD
LAND IN FORMATION (EXECUTIVE SIGNAL) APPLICABLE TO AIRFCRAFT IN TWO SHIP FORMATION ONLY		BEAT THE PALM ON THE OPPOSITE SHOULDER
CHANGE RADIO CHANNEL (EXECUTIVE SIGNAL)		BEAT HAND ON HEADSET THEN MAKE NUMBER OF NEW CHANNEL WITH THE FINGERS. FIST INDICATES FIVE EVERYTIME IT IS SHOWED. THEN SHOW FINGERS AS NECESSARY TO MAKE THE REQUIRED NUMBER
SPEEDBRAKE IN OR OUT (WARNING SIGNAL) . APPLICABLE ON THE GROUND TOO . EQUIVALENT TO EXECUTIVE SIGNAL OF CREWCHIEF		OPEN UP FIST OR CLENCH FIST TO INDICATE EXTENSION OR RETRACTION OF SPEEDBRAKE (FINGERS FORWARD PALM DOWNWARD)

391-1255

Figure 12-1. Normal Visual Signals (Sheet 3 of 4)

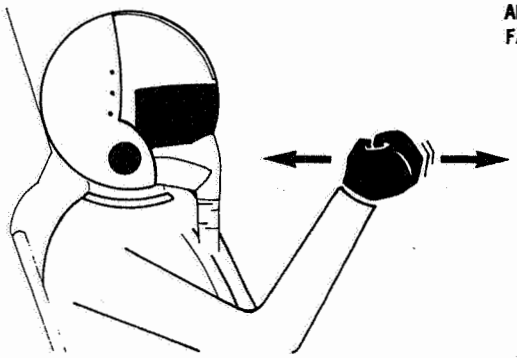
LOWER OR RETRACT THE LANDING GEAR (EXECUTIVE SIGNAL)

MAKE GESTURE PRETENDING THAT A HANDLE IS PULLED FROM UP TO DOWN OR VICEVERSA. FOR PREFORMANCE, DO NOD

LOWER OR RETRACT FLAPS (ADVISORY SIGNAL)

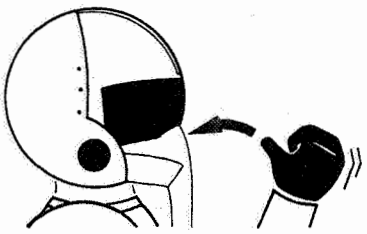
HAND INITIALLY STRETCHED OUT WITH PALM DOWN AT HEAD LEVEL. ROTATED FINGERS DOWNWARD PIVOTING ON KNUCKLES TO INDICATE TO LOWER. VICEVERSA TO INDICATE RETRACTION. FOR PERFORMANCE, DO NOD

CHANGE POWER SETTING (EXECUTIVE SIGNAL)



ADVANCE OR MOVE BACK FIST AT FACE LEVEL

REQUEST OF REMAINING FUEL QUANTITY (EXECUTIVE SIGNAL)



GESTURE OF THE PERSON WHO WANTS TO DRINK.
REPLY WILL BE:

- SHOW AS MANY TIME AS REQUIRED (EACH TIME INDICATES 500 KG), THEN THE STRETCHED OUT FINGERS (EACH FINGERS INDICATES 100 KG) TO INFORM AMOUNT OF REMAINING FUEL. SHOW CLENCHED FIRST AND THEN RAPIDLY OPEN AND CLOSE FINGERS: THIS MEANS THAT FUEL LOW LEVEL CAUTION LIGHT IS ON

391-1256

Figure 12-1. Normal Visual Signals (Sheet 4 of 4)

They are used in the two-ship formation. In larger formations, orders are given through the radio.
To obtain a simultaneous accomplishment of a direction given visually (as shown hereafter), the EXECUTIVE signal (sharp nodding) must always be preceded by the advisory signal.
These signals must in turn be acknowledged by the wingmen (nodding).

e. Emergency Visual Signals (fig. 12-2)

They are covered by a NATO agreement but are commonly used in many AIR FORCES and must be used for communication in case of an in-flight radio failure.
To draw leader's attention, move up to his position and rock the wings (in daytime) or flash the navigation lights (at night).
Flashing of the individual flashlight means EMERGENCY.
The leader must assume that the signalling aircraft has one or more inoperative systems and must therefore proceed with great care.

f. Responsibilities of the Leader

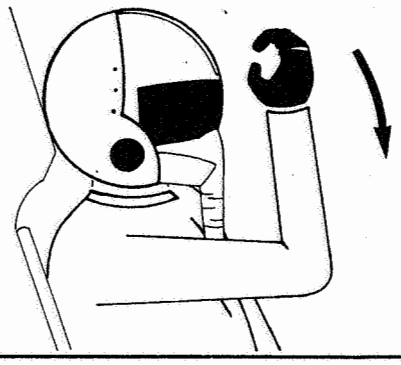
The leader must know the capabilities of his wingmen. During every maneuver, he is responsible for:

- Clearing
- Navigation
- Smooth change of power and attitude
- Maintaining enough altitude also in consideration of the fact that the other aircraft in the formation fly lower (especially during attack formation pullups).
- Knowing the ground position to inform the new leader when changing position from leader to wingman.
- Compliance of flight maneuvers with pre-briefed planning.
- Check of availability of sufficient fuel and oxygen for all aircraft in the formation (frequent checks).
- Avoiding the performance of some maneuvers, such as speedbrake lowering in IMC or in slot formation.

g. Responsibilities of the Wingman

The wingman must trust his leader. During maneuvers the wingman must not "blindly" follow the leader; he must conversely remain fully aware of orientation and attitudes and, without removing attention from the leader, he should maintain a sight of the outside, for safety reasons.
The wingman must constantly remember that DISCIPLINE and SELF-CONTROL are essential parameters, in particular during this type of flight.
He must be prepared to return to the base alone or, depending on the circumstances and his skill, to take the lead.
He must be familar with and implement the procedures applicable to formation flying and the special ones inherent in piloting and control (in normal and emergency conditions) of the single aircraft.
The wingman must keep the leader in sight at all times.
If he loses sight of the lead for any reason, the wingman must break out of formation. The wingman should not try to regain position if the leader is not in sight, going blindly on, as this may be very dangerous.
The wingman should try to maintain exact position, however if flight conditions such as turbulence exist, or the leader is maneuvering beyond wingman's capabilities, the wingman should move to a slightly wider posi-

EJECT (IS EXECUTIVE)



MIME EJECTION THRICE PRETENDING TO PULL A UPPER EJECTION HANDLE.
REPEAT THREE TIMES TO BE SURE THAT IT IS IMPOSSIBLE THAT ANY OTHER GESTURE IS MISTAKEN FOR THE ORDER TO EJECT

LAND

MOVE HAND IN FINGERTIP UP ATTITUDE WITH FINGERS STRETCHED OUT AND PALM FACING DOWNWARD TO SIMULATE TRAJECTORY OF A LANDING AIRCRAFT

SYSTEM FAILURE

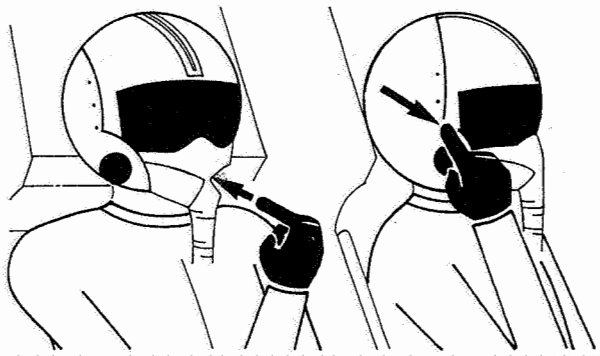
ROTATE FIST AT CANOPY TOP. THEN MAKE FINGER WELL VISIBLE WHICH CORRESPONDS FAILURE CODE:

H
E
F
O
E

1 = HYDRAULIC
2 = ELECTRICAL
3 = FUEL
4 = OXYGEN
5 = ENGINE

THE PILOT RECEIVING THE SIGNAL WILL REPEAT IT AS A CONFIRMATION THEN WILL NOD

RADIO FAILURE



REPEATEDLY TOUCH MICROPHONE AND HEADSET WITH FOREFINGER THAN NOD (IT OPERATES) OR SHAKE HEAD (IT DOES NOT OPERATE)

391-1257

Figure 12-2. Emergency Visual Signals

tion, i.e. a position enabling the wingman to continue following the leader.
The wingman must also try to avoid laziness as proficiency increase, thence he must always be concentrated.
The wingman should also think ahead to what the leader will do, thence to what he himself will do; this will enable him to pilot smoothly and without overcontrolling.

3. TWO-SHIP OR "ELEMENT" FINGERTIP FORMATION FLYING - PRE--FLIGHT OPERATIONS

TWO-SHIP fingertip is the basic formation including two aircraft. The leader is called ONE or LEADER and his task is to lead the formation for which he bears a full responsibility. The wingman, designated TWO, is responsible for maintaining the position with respect to the leader according to the received directions.
During flight in two-ship fingertip formation, the wingman must be trained to maintain position both at the right and the left of the leader.

a. Briefing (for any kind of formation)

A formation flight commander is designated for each flight in formation. The formation flight commander will ensure familiarity with forecast weather prior to the briefing. He will held a detailed briefing to all formation aircrews.
During the advanced training phases, a wingman can be trained to hold the briefing under leader's supervision.
The briefing will include at least the following items:

(1) Overview:

- Ground operations, taxi, formation call sign, positions of all formation members, engine start-up time, radio calls, taxi procedure.

- Flight commander/deputy flight commander (if needed). Procedures for lead change in flight.

(2) Additional items:

- Alternate mission (if applicable).
- Alternate airfield.
- Fuel bingo (destination and alternate airfields).
- Rejoin, overshoot, collision avoidance, breakout procedures.
- IMC procedures.
- Wake turbulence.
- Airspace clearances.
- In-flight checks (visual signals).
- Lost wingman procedures.
- Three-ship procedures (from four-ship formation).
- Wing landing procedures (if applicable).

(3) Take-off procedures. Aircraft position on the runway, visual signals, leader power setting at take-off, spacing during take-off run, visual signals for landing gear and flaps up.

(4) Climb. Percent RPM to climb, rejoin procedure, radio channel change, climb and checks.

(5) Cruise. Level-off and required power setting, position, turns and actions, type of formation, change procedures, break-out procedures, speedbrake signals, leader change, fuel and oxygen checks.

(6) Inbound. Type of approach and power setting, pre-descent checks, radio channel changes, traffic entry.

(7) Pattern and landing. Type of formation, power setting, configuration, pitchout procedure, landing position, after-landing procedure, go-around procedure.

b. Boarding the Aircraft

After completing the exterior checks the pilots will position in front of the aircraft, and the leader, after receiving a signal from the wingman (wingmen), will wave his arm to indicate that the aircraft is to be boarded.

c. Engine Start Up

Engine start up is carried out:

- When so directed by the leader if aircraft are parked close.

- Immediately after boarding the aircraft or after receiving direction to do so from the leader through the radio on the pre-briefed frequency if aircraft are not parked close.

NOTE

Any malfunction that may delay start up must be advised to the leader.

d. Radio Calls

The leader carries out a radio check on the pre-briefed frequency channel; he will then accomplish channel changes only after the wingman (two-ship fingertip) or the wingmen (4-ship flight) have ackowledged the new channel.
In case of missing radio contact on the new frequency, it is necessary to switch back to the previous frequency and wait for directions.

e. Taxi

Taxi clearance is requested by the leader only, who repeats the received instructions on the formation frequency. Before leaving the parking, the formation members call: "No. 1, leaving; No. 2, leaving".
Under normal conditions, aircraft spacing during taxi should not be less than 50 m to avoid FOD, and the aircraft must be in staggered positions with respect to the taxiway centerline, except in the area immediately before line-up. If taxi is made in the jetwash of the preceding aircraft, 100% oxygen shall be selected.

f. Runway Lineup

Every aircraft reports "canopy locked" to the TOWER. When receiving clearance from the tower:

- The leader lines up at center of the downwind half of the runway;

- The wingman lines up in the other half of the runway in a position seeing the internal tip tank along the runway centerline and the aircraft nose in the two-ship fingertip position (the wingman must see the leader

tip tank aft-end aligned with the leader rear pilot's head) for longitudinal spacing (fig. 12-3).

NOTE

In case of zero wind, or headwind or tailwind, the leader will line up so that the wingman is on the outside of the first turn to clear the traffic.

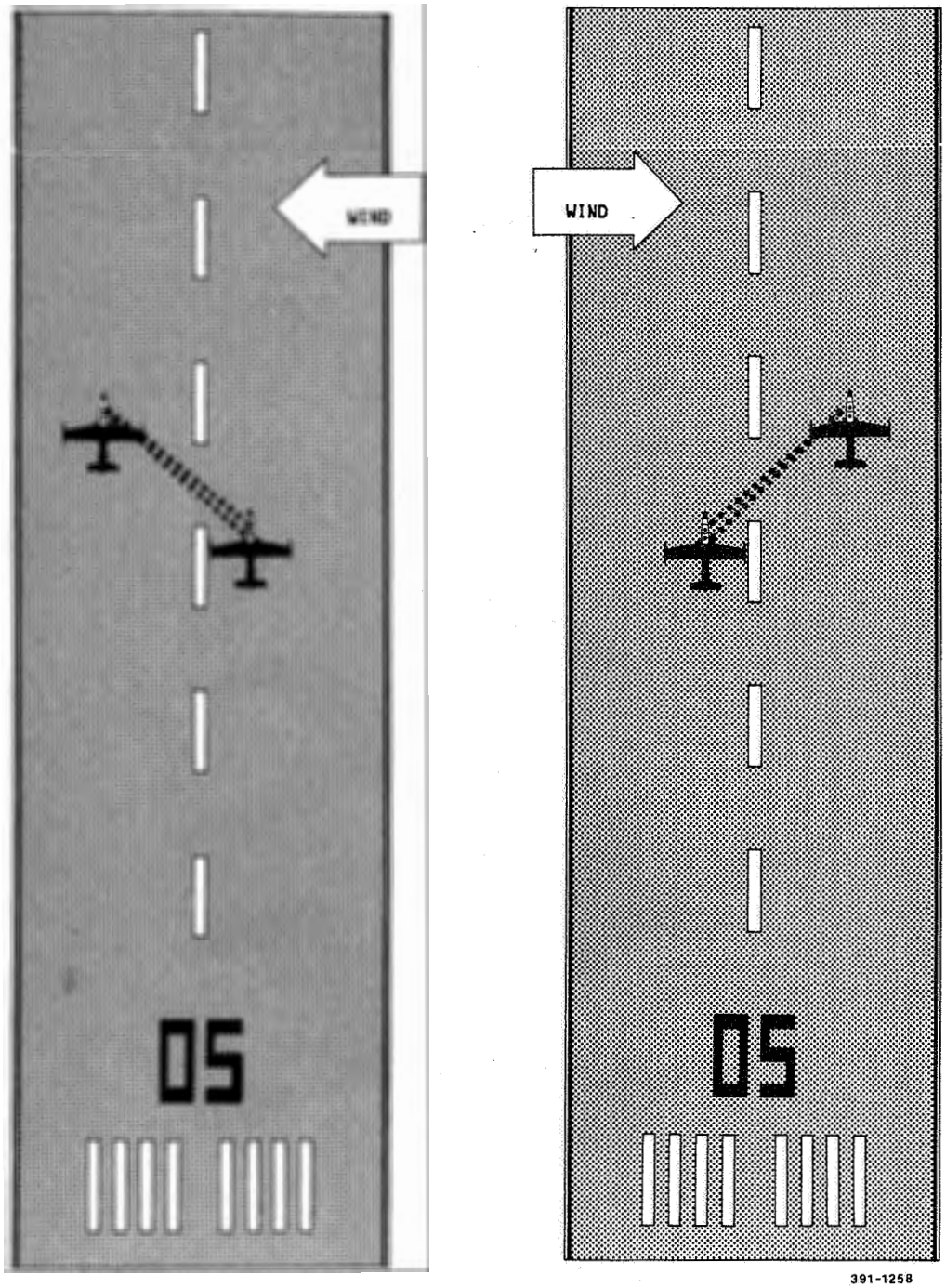


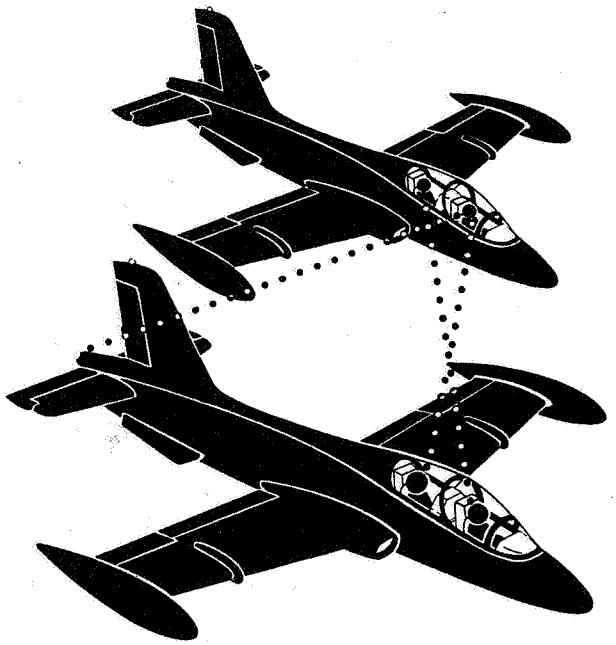
Figure 12-3. Two-ship Lineup on Runway

g. Runup and Checks

Before starting runup, the leader will ensure that the wingman is ready moving the ailerons or nodding the head; the wingman, if ready, will acknowledge by nodding his head.
Then the leader directs the wingman to perform runup and the relevant checks by rotating the forefinger upward. After runup completion, the leader will reduce power to 96% and the wingman to 97%. A new nod of the wingman will indicate to the leader that the wingman is ready for take-off.

4. TWO-SHIP FINGERTIP FORMATION FLYING - FLIGHT CONDUCT

In two-ship fingertip formation flying, correct position is maintained if longitudinal, lateral and vertical separations are maintained.
The wingman position is approx. 45° aft of the leader, therefore the pilot in the front seat should align the aft end of the wingtip tank with the head of the pilot in the rear seat of the leader.
As to lateral separation, a 1-meter wingtip spacing should be maintained: one method to obtain this result is to view the leader tail at approx. 90°.
Eventually, as far as altitude separation is concerned, the most expedient way is to see the same amount of leader wing top and bottom surfaces (fig. 12-4).
While maintaining longitudinal spacing, it should be remembered that response to throttle lever displacement is the fastest the highest the engine setting is. Besides, every correction envisaging action on the power setting and flight controls will be more accurate the more timely this action is, with small changes of engine setting and deflection of controls.
The procedures and maneuvers encompassed in the training program are detailed hereafter.



391-1259

Figure 12-4. Position of Wingman in the Two-ship Formation (Sheet 1 of 2)

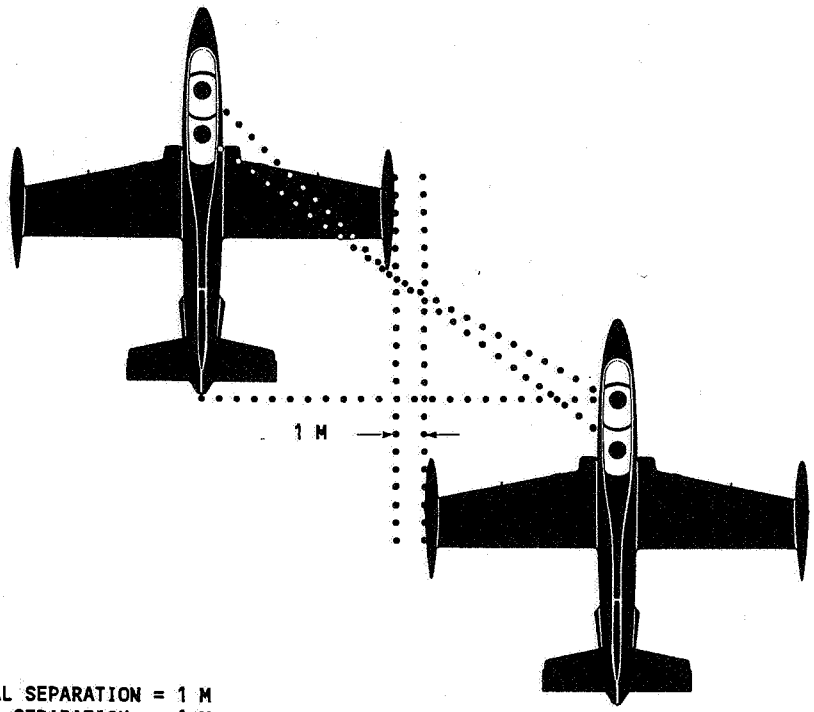
a. Two-ship Fingertip Formation Take-off

(1) Ground run. After receiving take-off clearance, the leader will visually direct brake release; upon executive signal, the wingman will release the brakes concurrently with the leader.
During the take-off ground run, the wingman must:

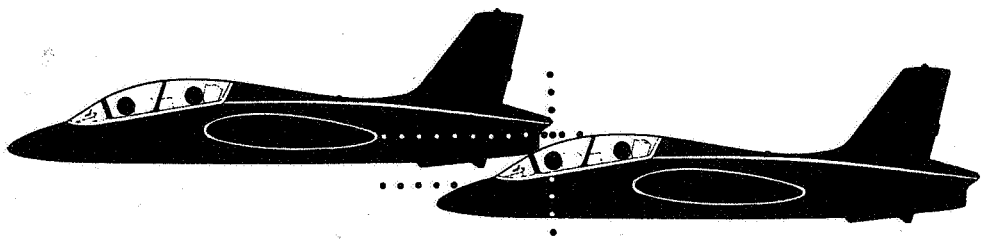
(a) Maintain longitudinal and lateral spacing using both throttle and flight controls.

(b) Start rotation concurrently with the leader. If either aircraft aborts in this phase, both aircraft will abort.

(2) Lift-off. During lift-off, avoid sharp control applications and fly all maneuvers to duplicate leader's action.



- VERTICAL SEPARATION = 1 M
- LATERAL SEPARATION = 1 M
- HEAD AT LEVEL OF LEADER'S JET PIPE
- ALIGN TIP TANK END OF LEADER WITH HEAD OF REAR PILOT



391-1260

Figure 12-4. Position of Wingman in the Two-ship Formation (Sheet 2 of 2)

In this particularly difficult phase, bear in mind the following:

(a) If either aircraft is compelled to abort, the other will normally continue the take-off following the instructions of the OPS;

(b) If lift-off occurs concurrently with the leader, avoid moving below the leader but maintain the same height until landing gear and flap are retracted.

(c) If taking off before the leader, remain just above the ground until the leader has taken off.

(d) If overrunning the leader, slightly reduce power and possibly delay retraction of landing gear and flaps.

(e) Landing gear and flap retraction is made by duplicating leader's action or because so directed visually.

(f) After completing the post-take-off checks, take the correct fingertip position.

b. Individual Take-Off and Rejoin

After completing engine runup, both pilots will leave RPM at 100%.
After calling the TOWER and obtaining take-off clearance, the leader starts his take-off run to perform a standard take-off. The wingman will release the brakes with the pre-briefed delay (6 sec minimum). When about to reach an altitude of 1500 ft and a speed of 250 kts, the leader will enter a pattern turn with 30° of bank and concurrently reduce RPM to 90%.
The wingman will follow the leader initially banking the aircraft more than the leader to complete rejoin inside the turn, and taking care to reduce power setting with the required lead.
After rejoin, the leader will set power to 96% RPM.

c. Climb

To leave sufficient maneuver room for the wingman, the leader keeps power setting at 96% RPM and a speed of 250 KIAS during climb; these parameters should be stabilized when the acceleration point is reached. When directed by the leader, the wingman will take the route position. He will then change radio channel as requested and perform the following checks: JPT, fuel flowmeter, oil pressure, fuel transfer, altimeters, oxygen. Then he will resume the fingertip position.

d. Level-off

Before starting the level-off maneuver, the leader directs the wingman with a visual signal.
During attitude change the wingman must maneuver smoothly, and in a coordinate way to maintain position with respect to the leader.

e. Turns

The relative position of the wingman during turns must be the same as during level flight. When flying inside the turn, the wingman must move to a slightly lower position and reduce power setting. The first action is required not to intercept the leader's flight path. The second action is a consequence of the trajectory which envisages a shorter radius of turn with respect to the leader. When flying turns outside the leader, the wingman must move to a little higher position to remain on the same plane as the leader's wing, and increase RPM to fly a track with a larger radius of turn (fig. 12-5).

WARNING

The wingman must never go higher the leader (fig. 12-6).

f. Consideration on the Two-ship Fingertip Formation

During formation flying the wingman must take the utmost care to avoid overcontrolling the aircraft, that is to perform fast, stiff and not coordinated movements that prevent correct aircraft piloting, impair safety and tire the pilot.
On the contrary, it is necessary to act smoothly on the controls and implement suitable corrections.

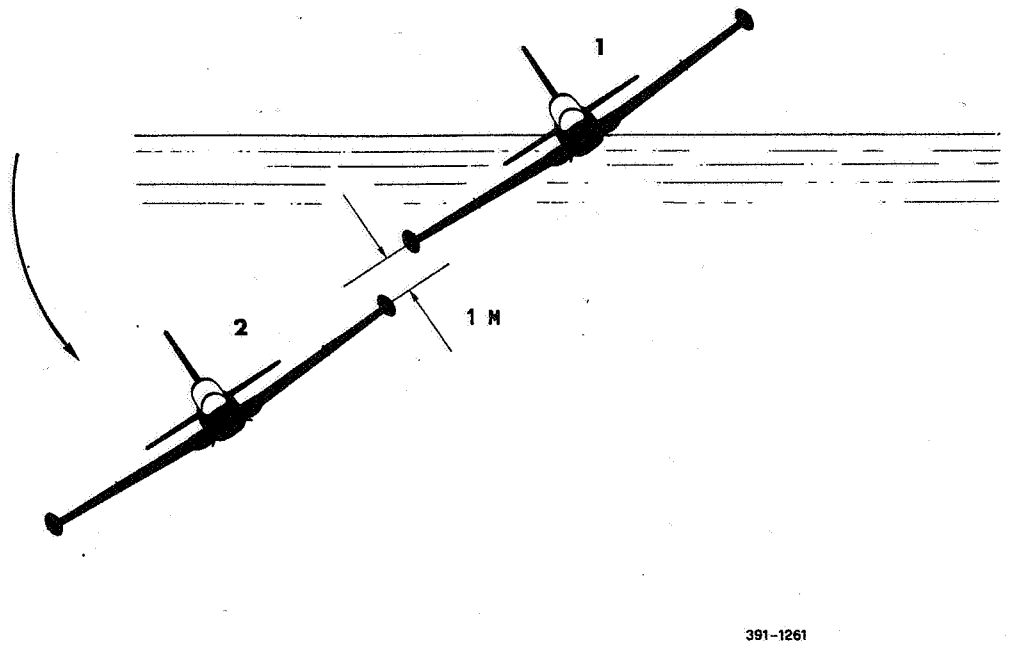


Figure 12-5. Position of Wingman During Turn - Into Position (Sheet 1 of 2)

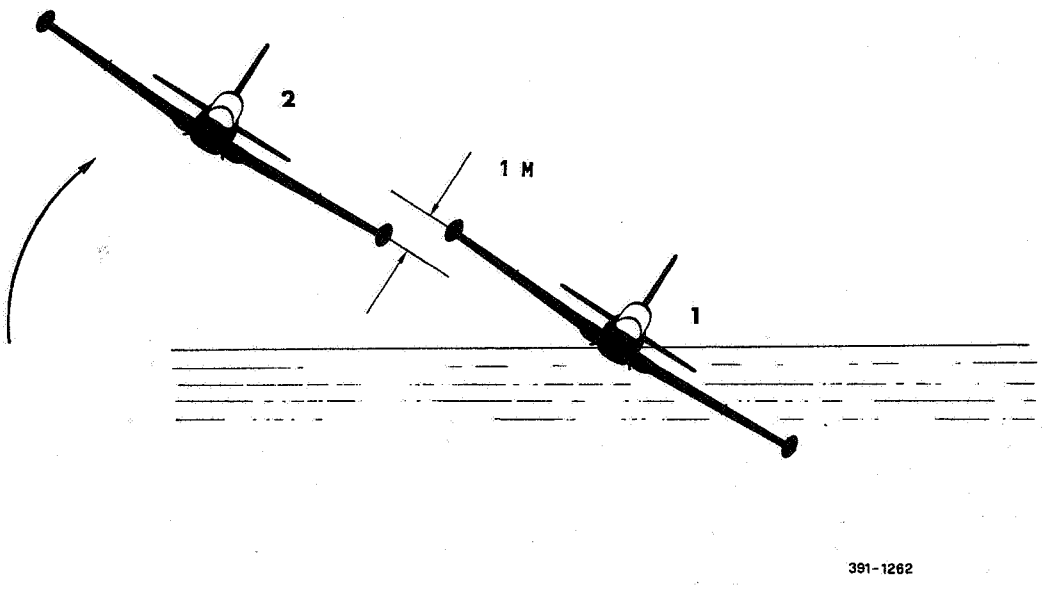


Figure 12-5. Position of Wingman During Turn - Away Position (Sheet 2 of 2)

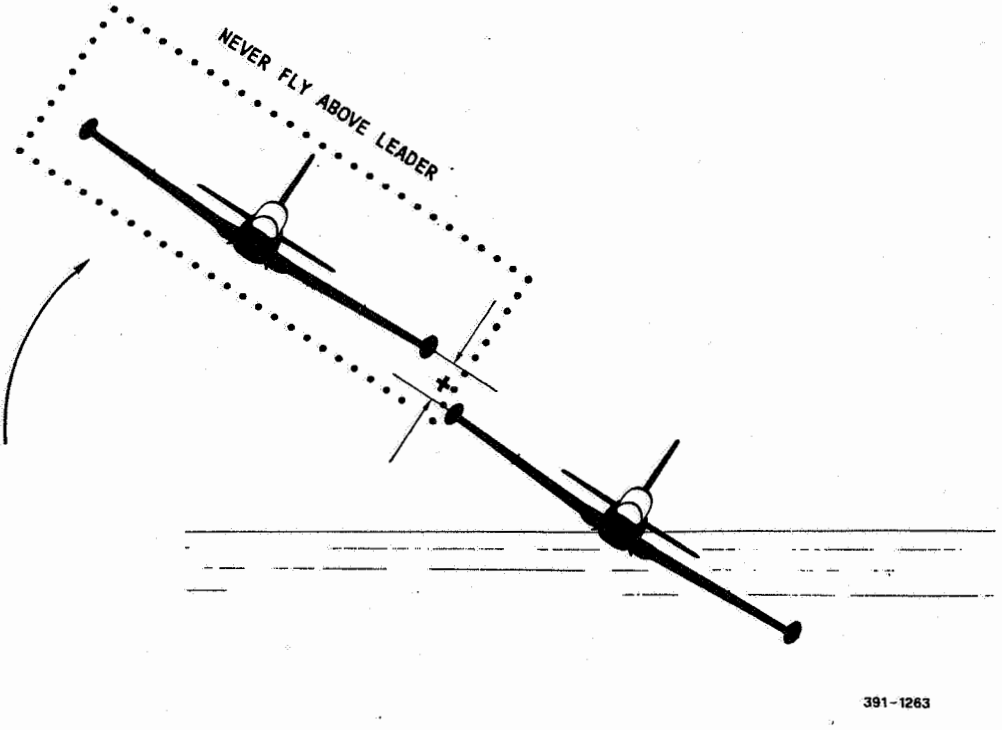


Figure 12-6. Wrong Position of Wingman

A frequent error, in particular in the initial phase, is to move to a too low position and increase spacing when flying turns outside the leader and to close up and go high in the turns inside the leader.
Another common error, due to tenseness on the controls, is to maintain the aircraft banked and concurrently apply opposite rudder to contrast bank.
In all phases of flight, the student wing plane must be parallel to the leader's wing plane. It is necessary to consider the leader's wings as a new horizon to use as a reference for lateral alignment.

g. Slot Formation

Spacings in slot formation are obtained as follows:

- Vertical separation: fin slightly below the leader's jetwash.

- Longitudinal separation: canopy arch slightly forward of the tail pipe of the leader. The wingman maintains position looking through the canopy and not through the windshield (fig. 12-7)

WARNING

When in close slot formation, avoid entering clouds; use the speedbrake only if absolutely needed, and only prior radio call indicating speedbrake extension.

h. Change from Wingtip to Wingtip

This change is the maneuver flown by the wingman to change his position with respect to the element leader moving down and aft. It is directed by the leader by means of a visual signal (fig. 12-1, sheet 5), or through the radio.

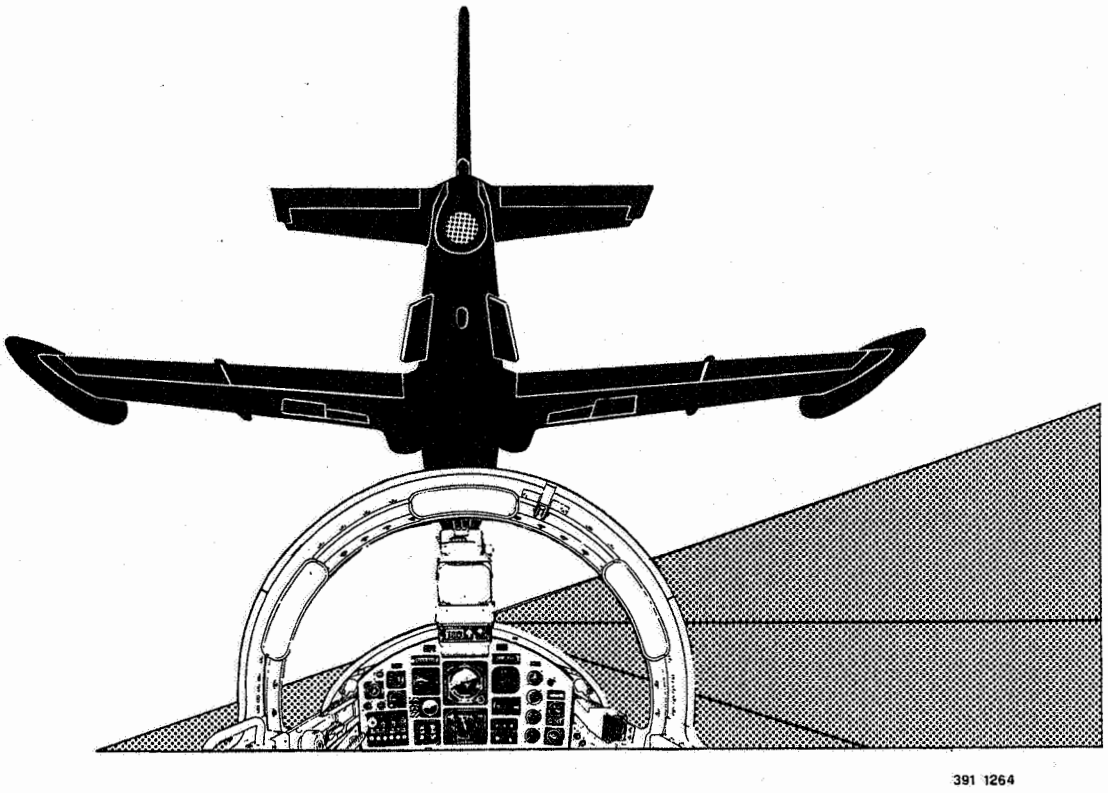


Figure 12-7. Slot Formation (Sheet 1 of 2)

If, for special reasons, the wingman believes he has to change his position, he must inform the leader of his intention before starting the maneuver.
The description of the maneuver has been divided into five phases, and is shown in fig. 12-8. The different phases must blend into each smoothly and with continuity.

i. Change from Echelon to Slot and Vice Versa

The purpose of this maneuver is to take a position behind and slightly below the leader.
The correct position is at half aircraft spacing from the leader, along its longitudinal axis and with an altitude separation of approximatively 3 meters.

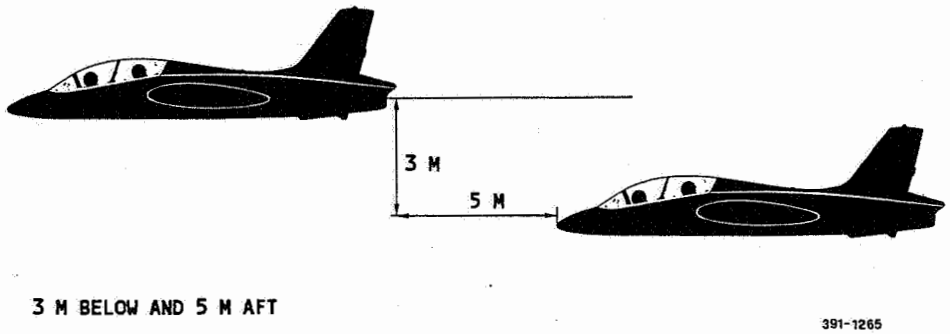


Figure 12-7. Slot Formation (Sheet 2 of 2)

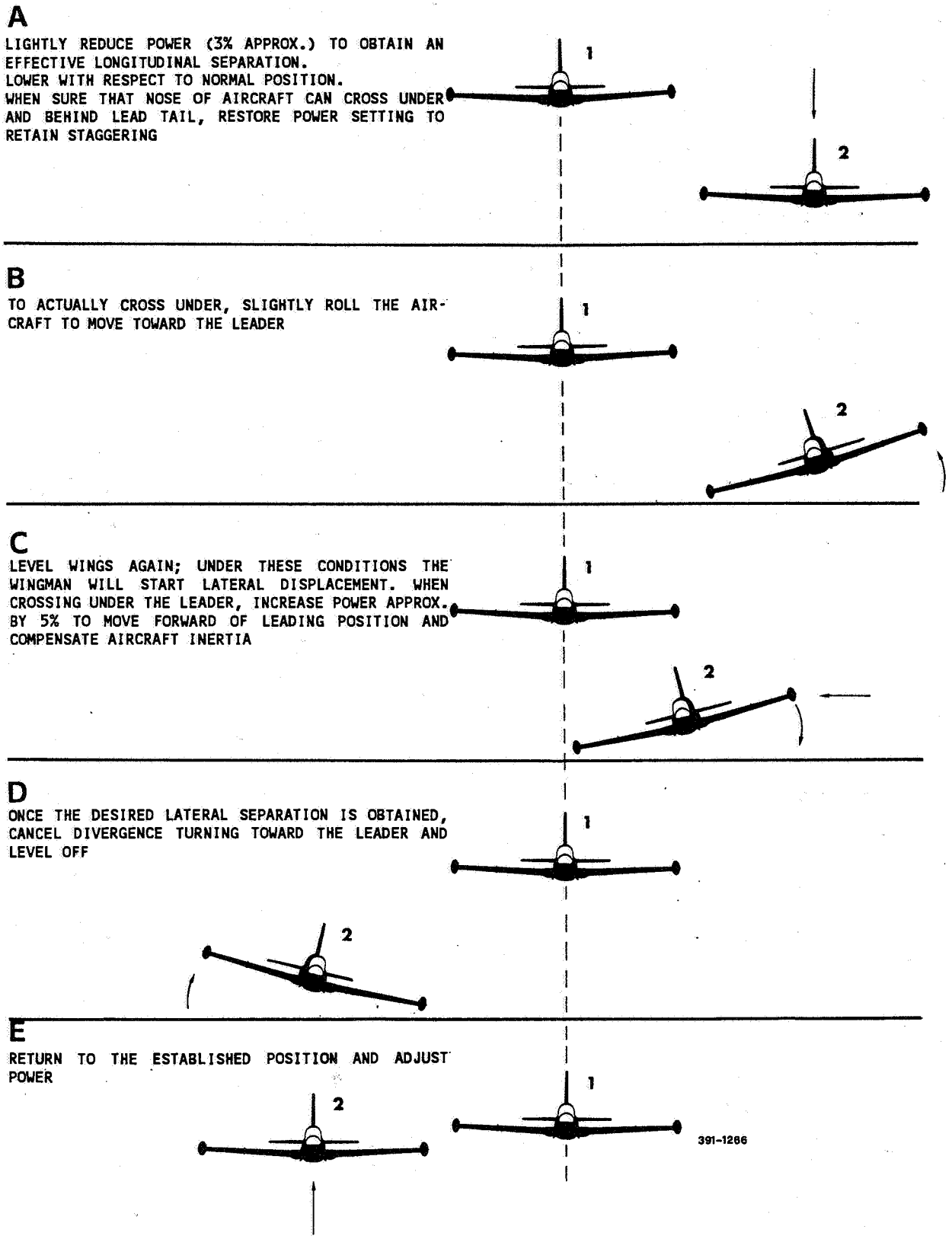

A
LIGHTLY REDUCE POWER (3% APPROX.) TO OBTAIN AN EFFECTIVE LONGITUDINAL SEPARATION.
LOWER WITH RESPECT TO NORMAL POSITION.
WHEN SURE THAT NOSE OF AIRCRAFT CAN CROSS UNDER AND BEHIND LEAD TAIL, RESTORE POWER SETTING TO RETAIN STAGGERING
1
2
B
TO ACTUALLY CROSS UNDER, SLIGHTLY ROLL THE AIRCRAFT TO MOVE TOWARD THE LEADER
1
2
C
LEVEL WINGS AGAIN; UNDER THESE CONDITIONS THE WINGMAN WILL START LATERAL DISPLACEMENT. WHEN CROSSING UNDER THE LEADER, INCREASE POWER APPROX. BY 5% TO MOVE FORWARD OF LEADING POSITION AND COMPENSATE AIRCRAFT INERTIA
1
2
D
ONCE THE DESIRED LATERAL SEPARATION IS OBTAINED, CANCEL DIVERGENCE TURNING TOWARD THE LEADER AND LEVEL OFF
1
2
E
RETURN TO THE ESTABLISHED POSITION AND ADJUST POWER
2
1
391-1266

Figure 12-8. Change from Wingtip to Wingtip Position

The technique is the same as that used to change from echelon to echelon. After reaching the correct position, it is advisable to limit control deflection during corrections, in particular during power and bank changes. Change from attack to echelon is flown with a technique similar to the one adopted from the final phase of a change from echelon to echelon.

j. Echelon Turns

In these turns the wingman, if out, flies in the same horizontal plane as the leader.
Longitudinal separation remains constant. The same applies to the lateral and vertical separation provided they are referred to a line of bearing across the fuselages. Therefore actual separations, viz. the spacings, remain unchanged.
At altitude, echelon turn is flown when directed by the leader. During pattern turns conversely, turn in this formation is flown without call as it is the procedure turn on traffic pattern.
Entry is flown by banking the aircraft at the same time as the leader and increasing power less than in echelon turns. This is done because the aircraft must not move up, but only turn, though over a path that has a greater curvature than the leader's path.
It is essential to maintain spacing and the same horizontal plane as the leader throughout the turn and during roll-out, which is effected in the same way, but in the reverse sequence with respect to roll-in.
In figure 12-9, note that lateral spacing seems to have decreased, and vertical staggering increased.

k. Trail

A formation is called a trail formation when the aircraft are one behind the other, at a given spacing and maneuver individually to follow the leader.
There are two types of trail formation:

- Extended trail
- Close trail

(1) Extended trail. This formation simulates the chase conditions when two aircraft have the same characteristics and fly at their best performance levels.
This condition is obtained when the two aircraft start practice at the same altitude, airspeed, power setting and attitude and maintain the initial RPM unchanged.
The leader gives the visual signal (as for break up) and flies a turn of approx. 180°; the first 90° on the flight line and with constant bank.

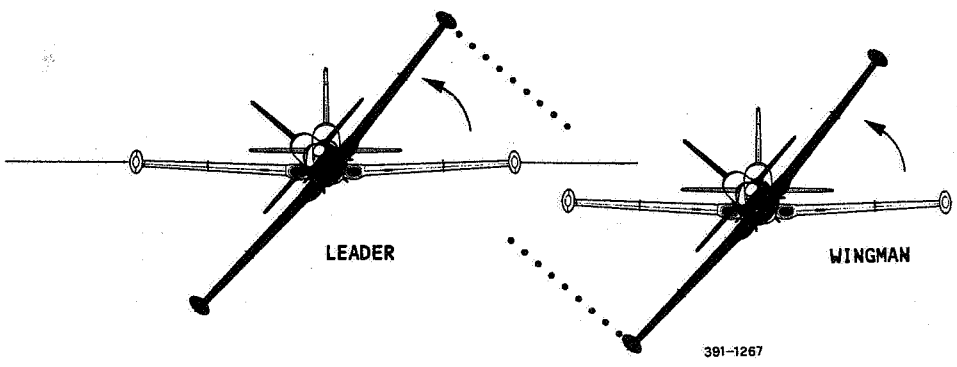


Figure 12-9. Echelon Turn

Normally 90% RPM is the required power setting; if not so, the leader will direct the power setting to use through the radio.
The wingman will fly an identical turn after flying straight for a number of seconds as decided by the leader.
The leader will then fly a straight flight path to enable the wingman to visualize the envisaged 400-500 m spacing (usually 3 to 4 seconds).
In the straight and level flight phases as well as in stabilized climbs and dives, the wingman's aircraft must fly a path parallel to the path of the aircraft in front of it, and displaced laterally by a spacing equal to half the wing span. The aircraft must fly trajectories in identical planes: this means that during maneuvered flight the wingman must duplicate all attitude changes of the leader at the trajectory points where the leader has accomplished them, thus not concurrently with the leader. As a consequence longitudinal spacing will not be constant: it will increase during dives and decrease during climb. The wingman must fly turns with the same turning radius as the leader: if he rolls in with lateral separation on the left, it is essential that roll out be with lateral separation on the right. Turn therefore involves a sort of "extended change" (fig. 12-10).
If it is needed to correct longitudinal separation with respect to the leader, trim or widen the leader's turn.
Remember: ALWAYS KEEP THE OTHER AIRCRAFT IN SIGHT

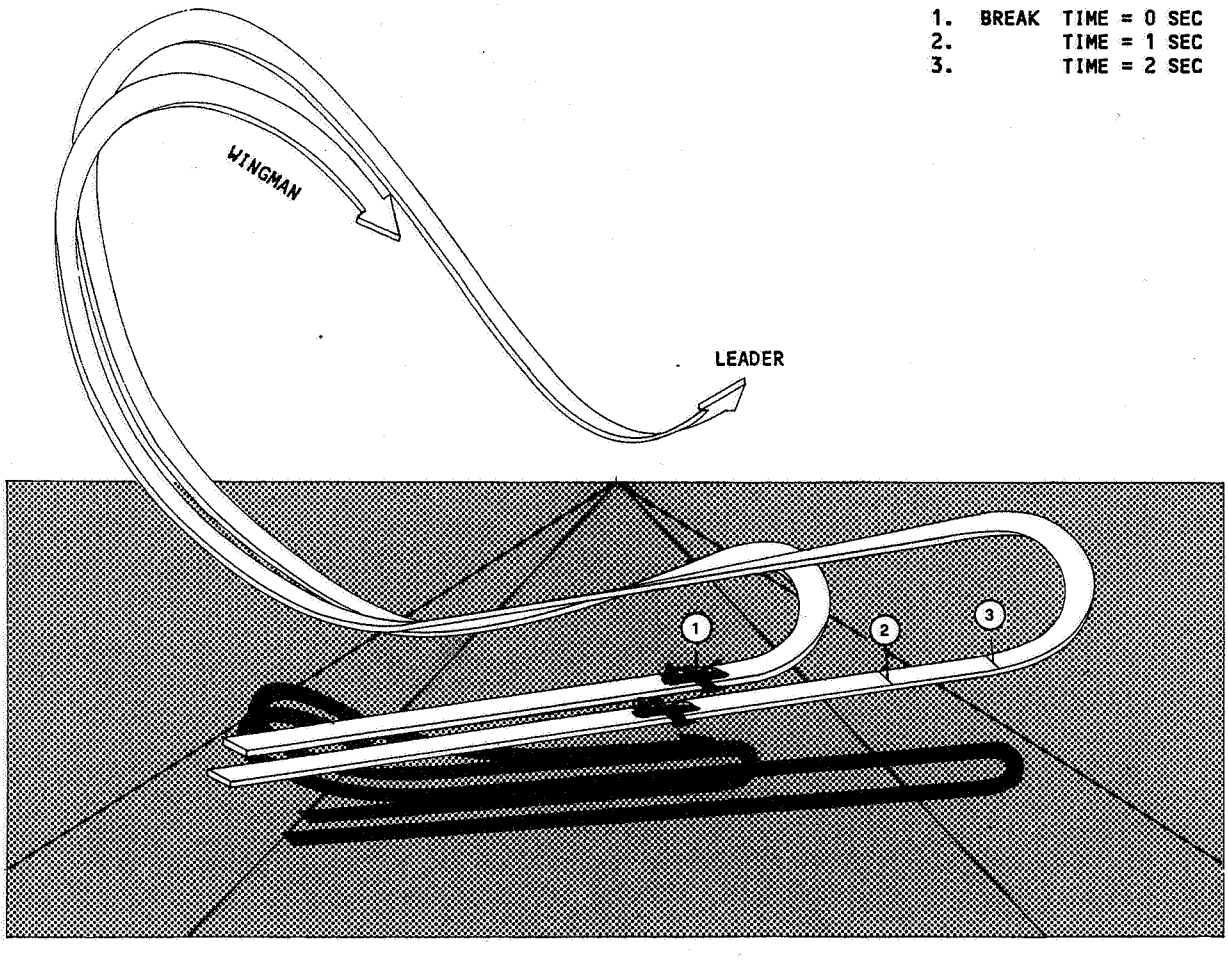


Figure 12-10. Break and Fly Trail Formation

NOTE

The above formation must be flown so that only just the top surface of the wing of the aircraft ahead is visible, to avoid entering its wake.

(2) Close Trail. The main difference between close trail and extended trail is the different longitudinal spacing, in the need to constantly maintain spacing and thus in the need to change power setting. Besides, vertical separation from the leader is different, as the wingman's position is lower.
The signal to "break up echelon" is the same signal as used for close trail. The leader starts a level flight 180° turn smoothly; the wingman follows the same maneuver with a little delay to separate of a distance of two or three aircraft while remaining slightly below the tail pipe of the preceding aircraft.
Above DISTANCE and POSITION must remain constant throughout the maneuvers. To correctly maintain position, it is necessary to see the leader's aircraft at center of the windshield (fig. 12-11) and keep it in this position: attitude changes occur nearly simultaneously.
Aerobatic maneuvers must always be separated from one another, and the leader must make sure that the aircraft are in the correct position before starting a new maneuver.
The altitude at which aerobatics is carried out, is the same envisaged for normal visual flying. It is necessary to remind that the most important thing is: TO KEEP THE LEADER'S AIRCRAFT IN SIGHT.

l. Rejoins

Rejoin is the maneuver permitting the aircraft to resume fingertip formation after flying trail.
The leader rocks the wings thus directing the wingman to rejoin; immediately afterwards he establishes a 30° level turn on the side in which he wants to rejoin and reduces power by approx. 2% RPM to facilitate rejoin (fig. 12-12).
The wingman will maintain power constant and move to the inside of the turn, sighting a point far forward on the leader's trajectory while remaining on the same horizontal plane, (not wing plane) of the aircraft ahead.
The initial cutoff angle depends on the spacing between the two aircraft: the greater the spacing, the larger the cutoff angle. As the maneuver progresses, and the wingman realizes that closure with leader is correc-

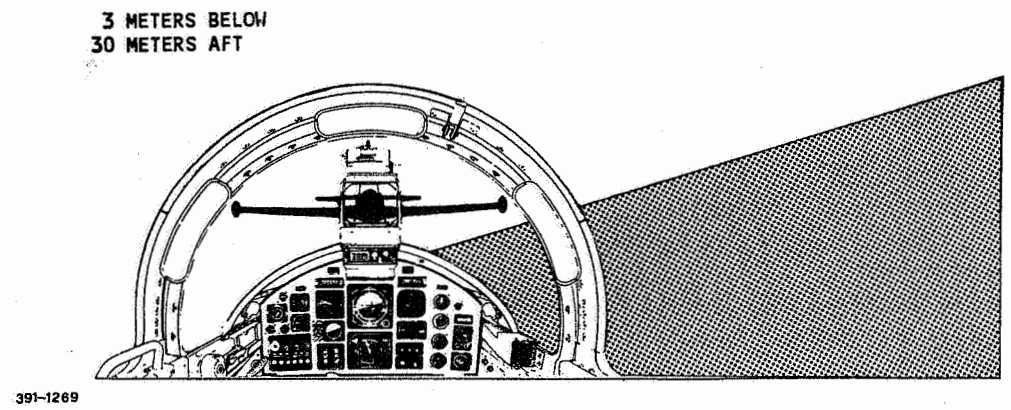


Figure 12-11. Close Trail

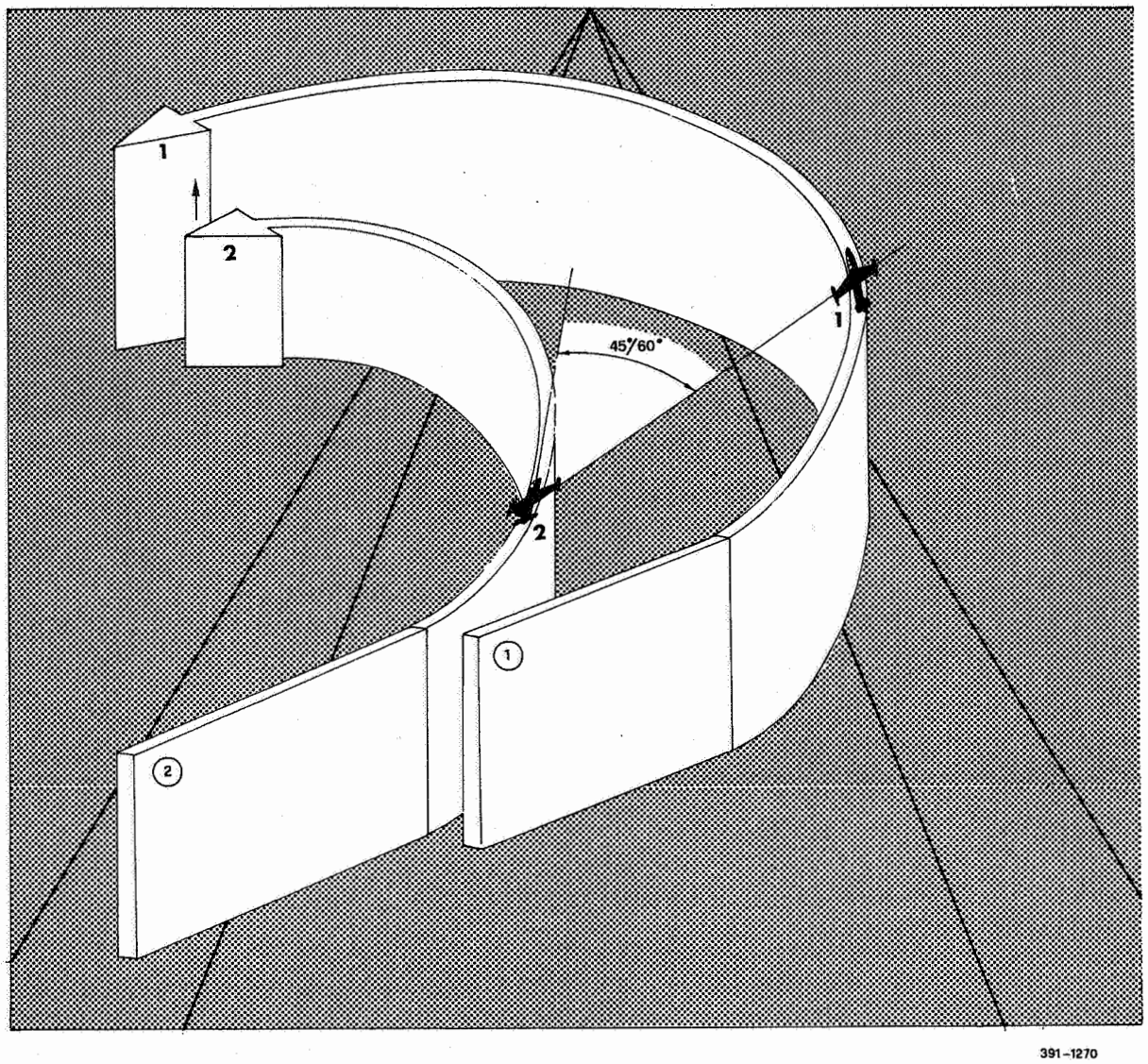


Figure 12-12. Rejoin

tly established, he will reduce the wing bank angle to have the leader at 45° on the side, then he will wait for a further slight increase of leader relative bearing.
He will repeat the maneuver until the desired lateral separation is obtained; the optimal integration of the above adjustments will give a continuous closure.
Avoid excessive cutoff angles as these would entail the need to further and much bank the aircraft to make the turn much steeper and would result in the wingman's wing hiding the leader, thus in a highly hazardous situation.
As the wingman gets closer to the leader, he should move further below him until a lower position with respect to the leader is obtained, so that the wingman has a sufficient crossunder clearance if closure speed should be too high (fig. 12-13).
If during rejoin the tendency to overshoot the leader is noted, the wingman should point toward the leader: this maneuver may seem to be against instinct, but it permits the flight path to be lengthened and longitudinal spacing to be increased. If on the contrary, tendency is to remain behind of the leader, or rejoin seems impossible, move away from the leader to decidedly cut away some of the leader's flight path (point far ahead).

If it is apparent that closure speed is too high (spacing rapidly decreasing), do not hesitate to reduce power setting and lower the speedbrake. Should this action be insufficient, decide overshooting with quite a lead (fig. 12-14).

(1) Wingman must always see the leader higher than the horizon.

(2) The wingman who decides to overshoot during turn, must immediately level-off the wings and pass below the leader and at least 20 meters behind him.

(3) Once on the side of the leader, slowly regain height.

(4) Absolutely avoid climbing too high. The leader must always be seen higher than the horizon.

(5) Bear in mind that pulling up to climb also reduces the radius of turn closing up on the leader.

WARNING

When rejoining outside of the turn, constantly maintain the leader in sight. As you notice that you tend to go higher than the leader, break formation to the outside.

m. Break Out

It is the duty of the wingman to leave the formation:

(1) Whenever directed by the leader

(2) Whenever he loses sight of the aircraft ahead

(3) Whenever he is unable to join up or to stay in formation without crossing under or in front of the leader

(4) At any other time he feels that his presence in the formation constitutes a hazard.

When the wingman leaves formation, he must notify the leader, and concurrently clear in the direction of the break to ensure that no other

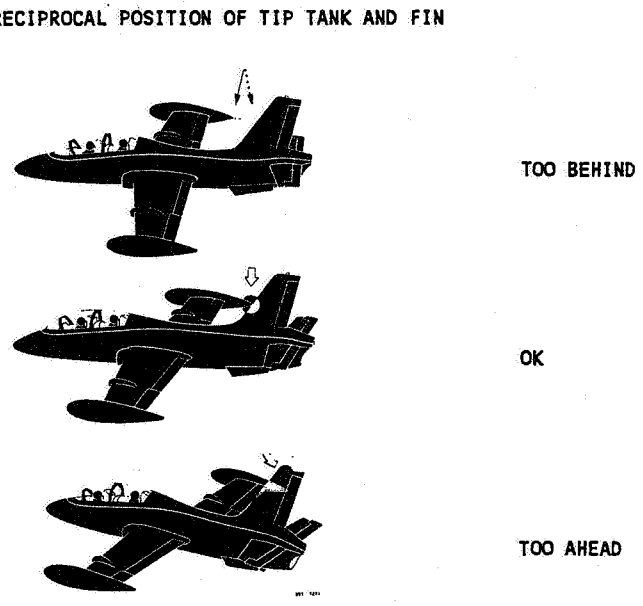


Figure 12-13. Position of Lead Aircraft as Seen from the Wingman During Rejoin

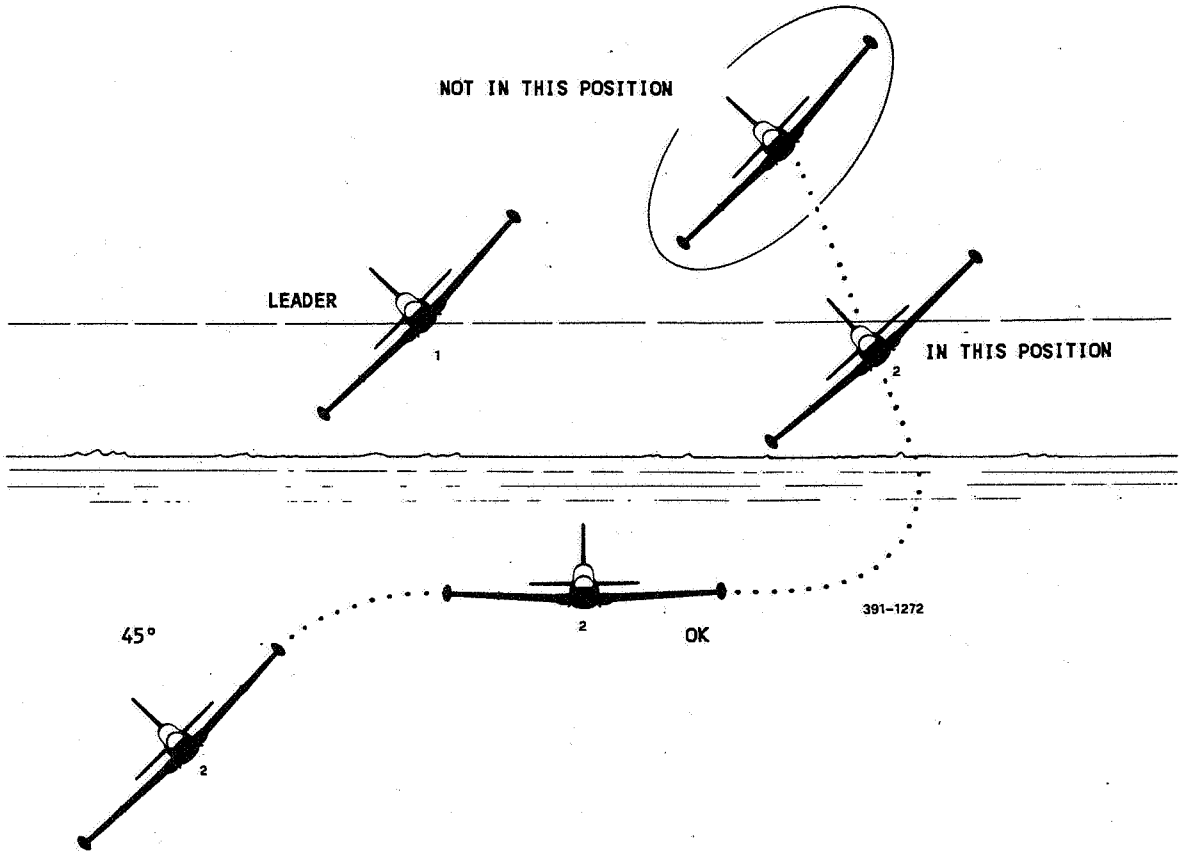


Figure 12-14. Overshoot

aircraft is flying in that area, thus providing for mid-air collision avoidance.
A power reduction and/or the speed brake may be used to expedite separation.
It is imperative that the lead aircraft continues the maneuver and maintains the established power setting.
If the leader has the wingman in sight when the wingman calls "breaking out" and can maneuver to aid in obtaining separation, the leader should do so.
A pilot who has left formation must not rejoin until permission is obtained from the leader.

WARNING

If the wingman must break out of formation during final approach (low altitude and airspeed), he should use extreme caution. Abrupt application of the flight controls may bring the aircraft in uncontrollable conditions.
In a few cases, the break out maneuver can be replaced by a smooth and progressive action on the controls. In other cases (for instance: aircraft too close to the leader and higher than the leader) it is more important not to loose sight of the leader than break formation, therefore use only the rudder to move away from the leader while keeping him in sight.

n. Echelon Aerobatics

Thanks to its maneuvrability and plentiful available power, the MB-339A aircraft permits an easy and safe training in formation aerobatics. This

kind of air activity is aimed at refining the piloting techniques and teaching the pilot how to maintain position in formation also in extreme conditions, both operational and meteorological.
The aerobatic maneuvers envisaged in the training programme have a horizontal development (aileron roll) and vertical development (cloverleaf and loop).

(1) Horizontal aerobatics. The leader will maintain a constant engine RPM, and will fly the aileron roll taking care to change roll attitude slowly (above all during roll in) and constantly, applying a moderate positive load factor to fly barrel type maneuvers with recovery in a descending attitude.
The student pilot will have to carefully trim the aircraft and be ready to duplicate the maneuvers flown by the leader. Any delay in entering the maneuver will result in additional position errors and make recovery difficult.
Flight controls will have to be used in a coordinated way, avoiding sharp movements. In the final phase of the maneuver, the pedals should be applied in the direction of roll with small deflections to avoid moving laterally with respect to the lead aircraft.
Power changes of the wingman will be made as a function of the wingman position with respect to roll direction.

(a) Aileron roll on the outside. When rolling in on the outside, the wingman will have to increase power setting as sufficient to maintain position. When the inverted flight position is about to be attained, power setting will be reduced to counteract the tendency to overshoot the leader.

(b) Aileron roll on the inside. When rolling in on the inside, the wingman will have to decrease power setting as sufficient to maintain position. When about to reach inverted flight, power setting will have to be much increased to counteract the aircraft tendency to increase spacing with respect to the leader.

(2) Vertical aerobatics. The leader will fly the vertical maneuvers without changing power setting and taking care to remain coordinated and fly with constant attitude changes. The student pilot will maintain a not too closed up position and will keep the aircraft trimmed. He will then start the maneuver together with the leader maintaining wing alignment and normal lateral spacing by use of the ailerons, and applying back pressure on the stick to maintain normal vertical separation with respect to the lead aircraft.
A too low position during climb will require the use of a lot of power and will make corrections of pitch attitude at the top of the maneuver difficult, with risk of G-stall resulting from the low airspeed.
Engine setting will be increased during climb, though avoiding too sharp and wide changes. During descent, it will be necessary to slightly adjust power setting to maintain position.

NOTE

Training in formation aerobatics must be flown in full safety. A poor lateral and longitudinal control as well as an excessive vertical separation (too high) especially in the rolling maneuvers with the wingman inside the maneuver may determine hazardous situations and loss of visual contact with the lead aircraft.
Under these conditions, it is essential to break the maneuver. In this case enforce, if required, the techniques applicable to recovery from unusual attitudes, and inform the leader that visual contact has been lost. If the student

pilot is unable to rejoin, he must recover orientation, carry out the checks, switch on the radio equipment, possibly request for bearing, leave the airwork area, inform of accomplished break and go to landing.

o. Descent

(1) Visual descent. It is planned by the leader and carried out with not too strict parameters (RPM not below 78%, IAS from 250 to 300 kt, speedbrake as required), after performing the prescribed checks.

(2) Penetration. If it is intended to fly an instrument penetration, the leader must:

(a) Make sure during approach that minimums exist on the destination airfield that are compatible with his own and the wingman's instrument qualifications, and that a suitable alternate airfield is available, diversion to which may be possible, if needed.

(b) Make sure that checks prescribed before entering adverse weather have been accomplished.

(c) Use any possible action to facilitate the wingman in maintaining position (avoid clouds during turns, bear in mind that in IMC the wingman finds it easier to fly the base turn on the outside of the leader, avoid sharp turns during beacon interceptions, lower the speedbrake before entering clouds). Speedbrake extension is directed by a visual signal in VMC and by a radio call in IMC.

p. Pattern (fig. 12-15)

- Generally formation must complete level-off at pattern altitude and at a IAS of 250 KIAS, approx. 5 NM ahead of the initial point.

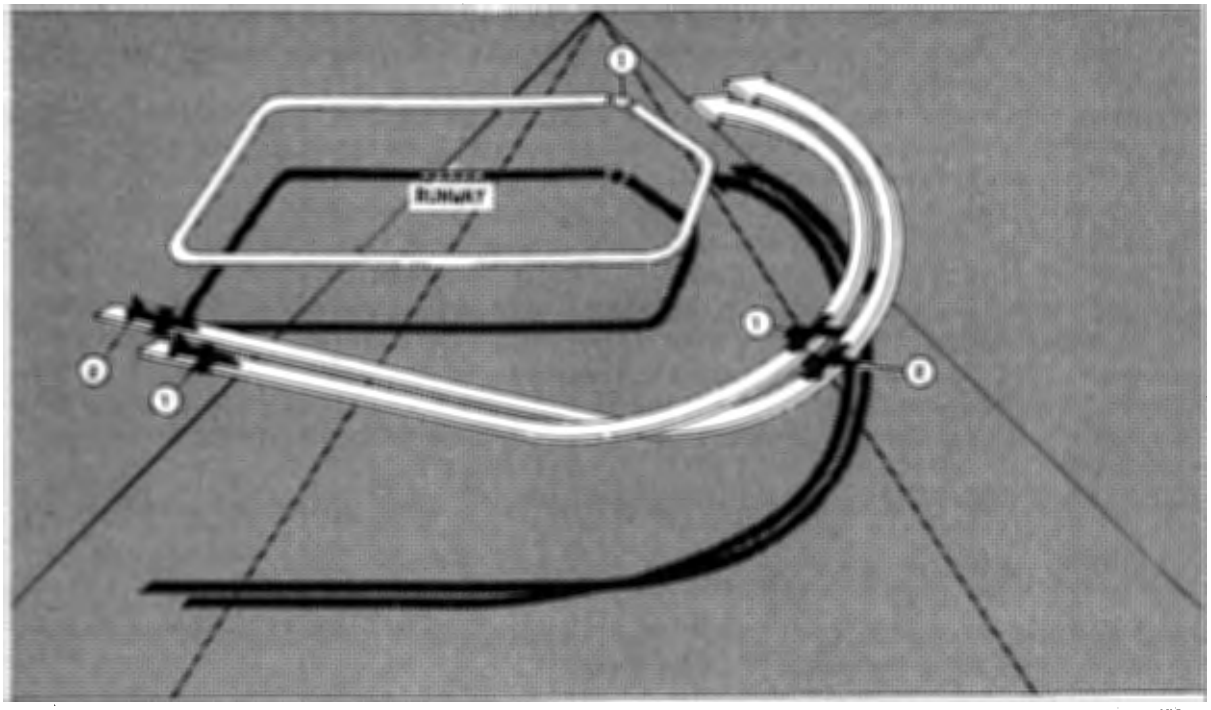
- The leader must inform the tower as to the ETA on the IP at least 2 minutes before reaching it, and then reach the IP with the wingman at the right echelon position if break is on the left, or the wingman at the left echelon position in the opposite case.

q. Break

Formation maintains echelon position up to the break point, then each aircraft carries out the maneuver individually by complying with the separation time directed by the leader (2 or 3 seconds).
The only "trick" is to reduce power setting and extend the speedbrake after attaining a bank angle of 45°.
The leader breaks a little earlier than usual, the wingman follows in the due time span trying to move to the trail position and slightly inside on the downwind leg. The landing gear and flaps will be extended on downwind by duplicating the leader's actions. It is not worth mentioning that the wingman becomes so to say 'independent' after break. He must therefore perform all maneuvers envisaged for an individual landing, but refer to the aircraft ahead as far as maintainment of both altitude and spacing is concerned.
Once on final, it is necessary that the wingman keeps the same trajectory as or a slightly higher trajectory than the leader to avoid jetwash, as this is directed downward.

r. Individual Landing

Touchdown and ground run occur on the runway centerline. After ascertaining proper brake operation, both aircraft move to the runway slow side to clear the runway hot side for aircraft having failures or going around.



I. INITIAL POINT
1. LEADER
2. WINGMAN

Figure 12-15. Pattern in Two-ship Formation

s. Two-ship Formation Landing

This landing is usually flown either from an instrument approach (TACAN, VOR, ILS, GCA), or for training purposes straight from the airwork area heading on the FAF that will be reached with the correct configuration and parameters.
The two-ship formation, when approaching the glideslope (2 to 3 NM ahead of the FAF in the case of TACAN procedure), will keep the following parameters for landing:

- Landing gear down (spedbrake up)
- T/O flaps
- 130 KIAS

Landing gear and flap lowering can be directed by the leader either through the radio or by visual signals.
The wingman maintains fingertip position bearing in mind that controls are more loose at low speed and therefore aircraft control is more difficult, thus large errors can be made up for with far greater difficulty.
From the moment in which final descent is started, the formation sets the flaps to down as just described and holds the following parameters:

- 120 KIAS
- 500 to 600 ft/min to descend
- 78% RPM
- "TAXI" light on

On short final (close to approach minimums) the wingman that up to that point maintains fingertip position, moves from slightly below to slightly

above the leader. Two-ship formation goes to landing in this configuration, that is with aircraft aligned on the same horizontal plane and each aircraft on a runway half.
When near to touch-down and at the appropriate instant the leader directs "engine off" in clear. The wingman complies and conveys his attention, up that point paid to maintain position, to the roundout and touchdown phases shortly glancing at the runway. The leader retards the throttle a little later and touches down slightly ahead of the wingman. During ground run, it is essential to carefully maintain direction.
If for a reason whatever, for instance because of traffic, it is necessary to discontinue approach, the leader will prepare for go-around calling 'power' and increasing engine setting to 96%. When power has stabilized, the landing gear and flaps will be retracted as detailed above. The wingman will duplicate all leader's maneuvers and maintain normal fingertip position.
Usually the two-ship fingertip formation will return to low approach.

t. Lost Wingman Procedures, Leader Out of Sight

It is essential to distinguish whether the wingman is lost in VMC or IMC, since the procedure to adopt is different.

(1) VMC. The wingman immediately calls the leader to tell that he has lost visual contact, then proceeds as directed by the leader.

(2) IMC. There are three cases:

(a) Climb:

- The wingman contacts the leader and the ATC activity advising them of the situation.

- The leader advances the throttle to full power.

- The wingman flies a 30° turn on the outside of the leader and maintains the heading flying straight for at least 1 minute to ensure separation, then turns to the original heading and complies with the directions provided by the tower.

- Rejoin will be flown only in VMC

(b) Straight and level flight:

- The wingman informs leader and ATC activity.

- The leader continues the normal procedure.

- The wingman carries out the same procedure as envisaged for climb

- ATC may, if necessary apply a vertical separation between the two ships.

(c) Descent:

- Then wingman informs leader and ATC activity.

- The leader continues the normal procedure

- The wingman stops descent and, after flying a 360° level turn away from the leader, restarts normal descent following the instruction of the ATC activity.

NOTE

In all above cases it is essential that continuous radio contact be maintained between leader and wingman, who will specify their altitude and position (bearing and DME distance).

5. FOUR-SHIP OR LARGER FORMATIONS

a. Premise

Aerotactical operational formations are usually formed by four (or more) aircraft and are often termed FLIGHT's.
The formations of more than four ships, are usually composed of several FLIGHT's and are used during air parades only.
Mass operation of aerotactical units makes use of several flights, which operate in a coordinated manner, but separately.
Aerotactical aircraft (with few exceptions represented by strike or reconnaissance aircraft) generally do not operate alone.
A four-ship formation is based on the two-ship element. The element cannot separate, while the four-ship formation can sometime separate into the two elements.

The flight usually operates in close or extended formations where the aircraft are arranged like the fingers of a stretched out hand (forefinger to pinky); this arrangement is termed fingertip formation or finger position (fig. 12-16).
The term FLIGHT indicates a four-ship formation divided into two elements. Every aircraft is assigned a number that defines its position in the formation.

First element: No. 1 leader - No. 2 Wingman

Second element: No. 3 leader - No 4 Wingman

The element cannot separate.

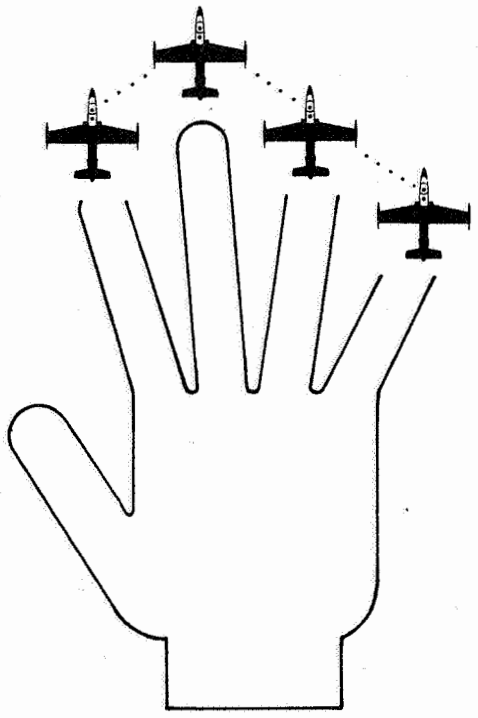


Figure 12-16. Four-ship Fingertip Formation

b. Pre-flight Operations

(1) Briefing - Radio procedures - Engine start up - Ground run. The same as specified for the two-ship formation applies.

(2) Line-up. The position of the four aircraft on the runway will depend on the wind direction (fig. 12-17). After take off and during the turn to leave the pattern, the leader will take care that rejoin of second element occurs on the outside of the turn, possibly envisaging a double change of number 4 and number 2 during the last acceleration phase. In case of zero wind conditions conversely, if turnout is envisaged to be flown on the left, the leader will line up on the right end of

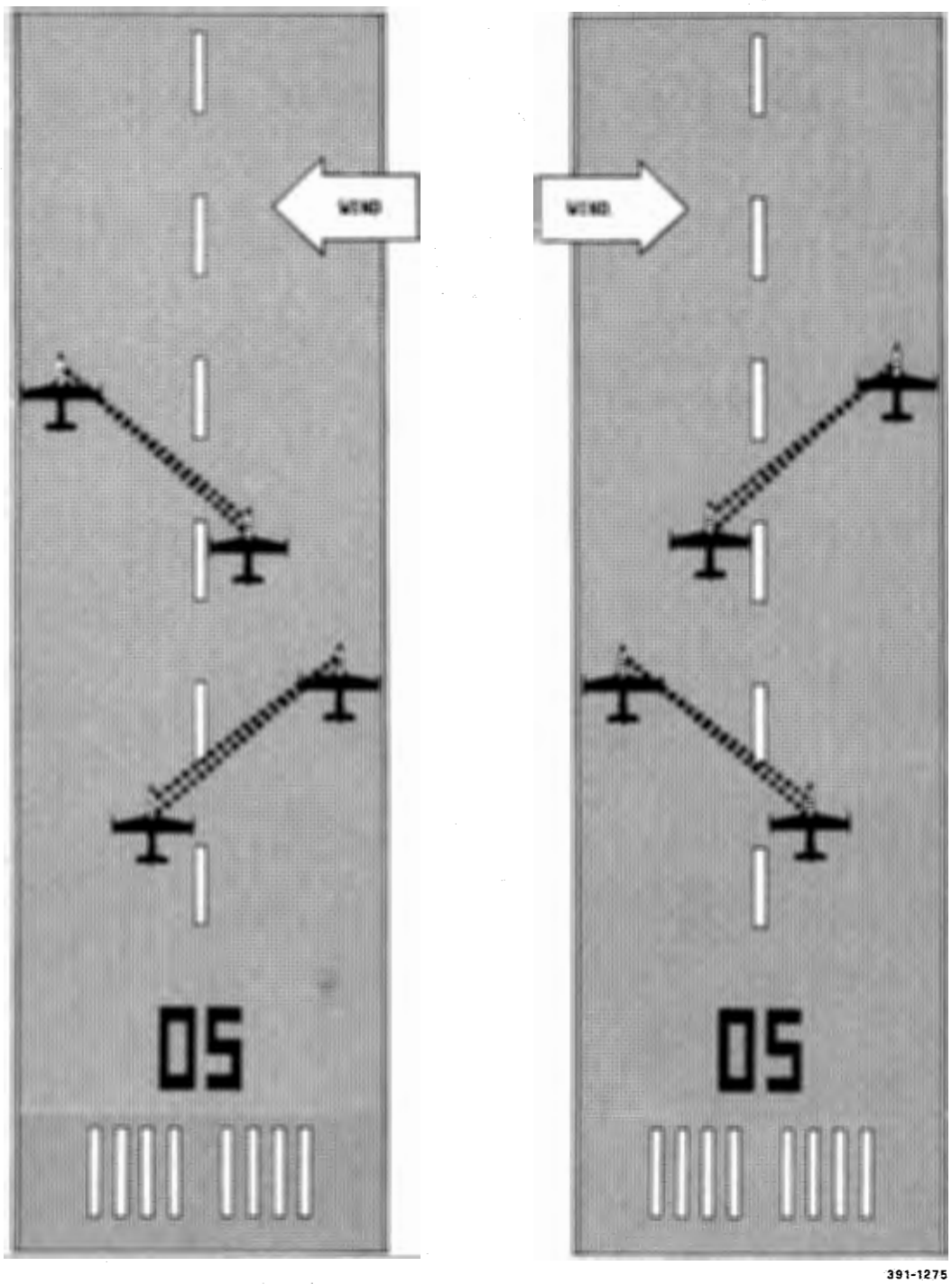


Figure 12-17. Lineup of "Flight" for 4-ship Take-off

the runway, number two will be on his left side (wingtip brushing the runway centerline), number 3 on the left end of the runway and number 4 will be on the right half of the runway, the left wingtip brushing the runway centerline (fig. 12-18).
If turnout is on the right, positions are reverse.
When all wingmen are ready, engine runup and the required checks are performed concurrently.
The visual signals of the leader will be repeated by No. 2 to No. 3 and by No. 3 to No.4. The wingmen will then nod their head to acknowledge and this signal will be repeated by each of them in sequence up to the leader, who will aknowledge by an OK.

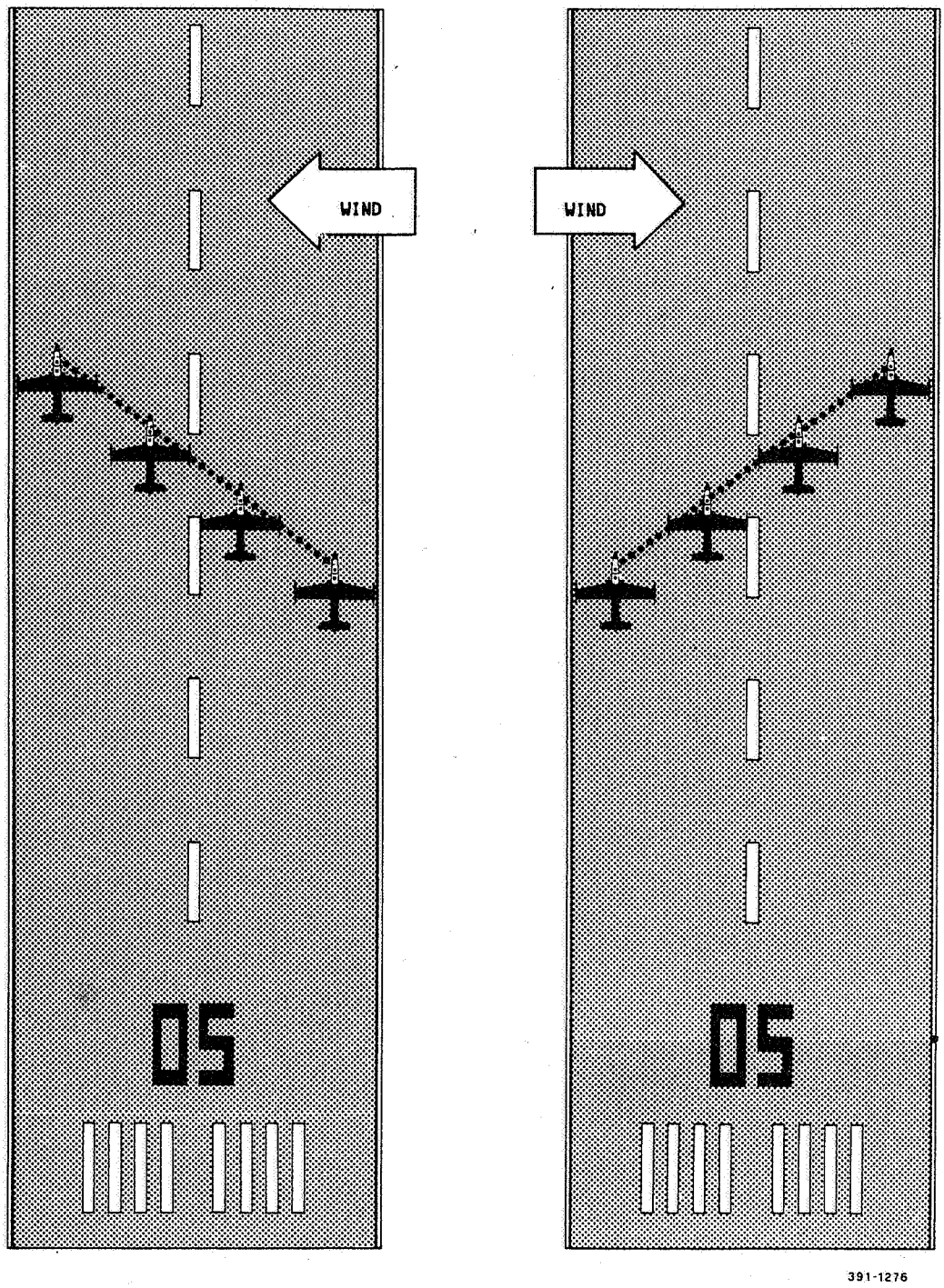


Figure 12-18. Lineup of "Flight" for Individual Take-off

After engine runup, the leader will reduce power setting to 96% RPM, No. 2 to 97% RPM, No. 3 to 98% RPM and No. 4 to 99% RPM, if take-off is by element.

NOTE

If the aircraft are to take-off individually, all aircraft will line up on the right with respect to the leader if wind is from the right, or on the left in the opposite case. After engine runup, the aircraft will maintain 100% power.

c. Flight Operations of the Flight

In the four-ship fingertip formation, each wingman uses the same procedures that he has learnt for the two-ship formation as far as spacing and separation from the aircraft ahead is concerned.
Formation is in the positions shown in the figure 12-19. It is advisable that No. 2 and No. 3 make sure that they have taken the same position with respect to the leader, while No. 4 will check his alignment with respect to No. 1 and No. 3.
The maneuvers and procedures envisaged in the program are described hereafter.

(1) Take-off in element. The take-off will be flown in separate elements. The second element will release the brakes 6 seconds after the first element.
No. 1 and No.3 will keep power setting constant at 96% and 98% respectively.
The first element will fly a longer than normal take-off and after lift off will maintain a slightly lower than normal flight path. The second element will conversely fly a standard take-off. In this way the second element will be at the same height as the first one after lift off (the first element is already aloft), thus avoiding the jetwash.

(2) Individual take-off. After requesting and obtaining take-off clearance from the tower, the leader starts his take-off run. The wingmen release brakes 6 seconds after each other.
The leader and No. 3 fly a longer than normal take-off and remain a little lower than usual after lift-off, No. 2 and No. 4 will conversely fly a standard take-off. In this way at lift-off they will be at the same height as the preceding aircraft (which is already far ahead), thus avoiding the jetwash. When No. 4 calls "airborne", the leader and No. 3 will take the normal climb attitude, that will be maintained in the subsequent flight phase.

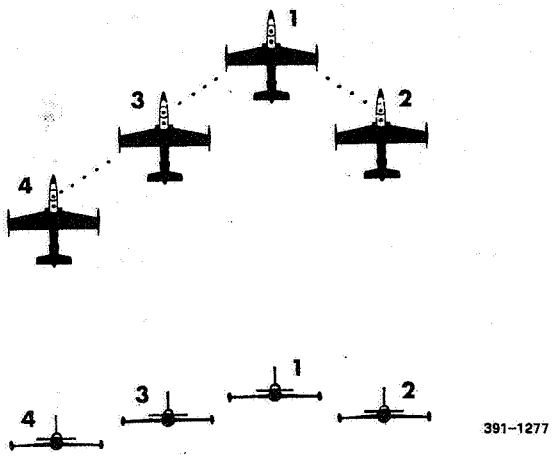


Figure 12-19. Fingertip Formation of "Flight"

(3) Joinup after take-off. Rejoin will change depending on the type of take-off accomplished.

(a) Joinup after element take-off.

- At an altitude of 1500 ft and an airspeed of 250 kts, the leader will roll in a 180°, 30° banked turn on the side of No. 2 while reducing power setting to 90%. During this turn, the second element will rejoin. Rejoin must always be effected outside the turn.

- If traffic reasons prevent the leader from flying the turn on the side of No. 2, he will direct No. 2 to change from the inside to the outside position. Subsequently, No. 3 and No. 4 will also change position so that the second element can rejoin outside the turn.

- Everytime at the acceleration point the leader decides to turn in a direction opposite to the pattern direction, he will have to inform the tower beforehand. For better air traffic coordination, this call should be done as early as line-up. If rejoin is not complete in the 180° turn and it is believed that airfield is to be overflown at an altitude equal to or lower than 8000 ft, the leader must request specific clearance to do so to the tower.

- After completion of rejoin, the leader will select 96% RPM and continue normal climb.

(b) Individual take-off

- When an altitude of 1500 FT and an airspeed of 250 kt are being approached, the leader will commence a 30° banked turn in the direction of the pattern while reducing power setting to 90% RPM.

- The wingmen will follow the leader initially taking a bank angle steeper than the leader in order to move to the inside of the turn. Maintaining power setting at 100% RPM, they will start rejoin; subsequent power setting reduction and possible speedbrake extension will depend on the closure rate.

- When rejoin is complete, No. 2 will always take the left fingertip position, while No. 3 and No. 4 will take the right fingertip position (fig. 12-20).

- If the leader is compelled to change the prebriefed flight parameters (airspeed and/or power), he must inform the wingmen of his situation.

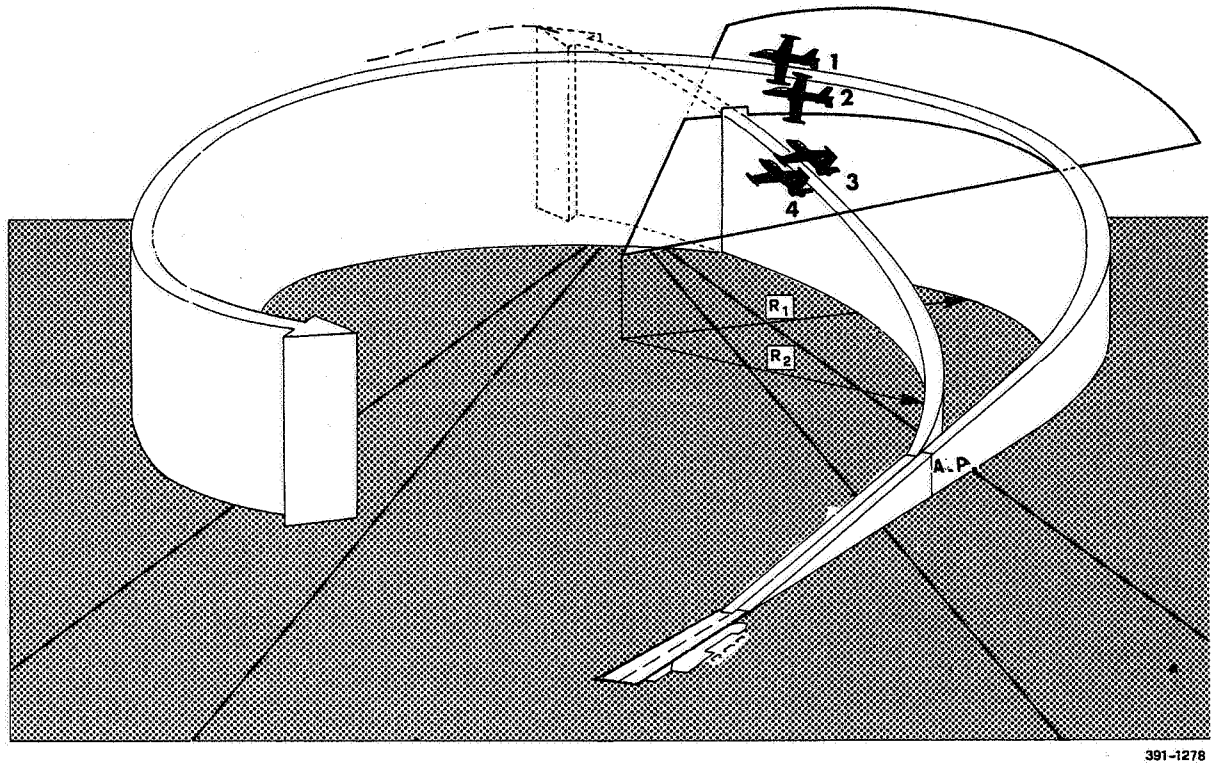
- When rejoin is complete, if it is required to continue a standard climb, the leader will select 96% RPM.

(4) Climb and level-off. The climb and level-off maneuvers will be flown in the same way and with the same parameters as in two-ship formation.

(5) Turns. During turns, the wingmen will hold the same relative position as in straight and level flight; the technique to fly turns is the same as during two-ship formation flying. Its is pointed out that No. 4 is required to change power setting more and with a greater lead with respect to No. 3 to compensate for the longer flight path flown (turns on the outside) or for the smaller curvature (turns on the inside).

(6) In-flight position changes (echelon)

(a) Techniques for position change. The technique used for position change is the same as used in the two-ship formation.
Position changes are made from fingertip to echelon and viceversa, and to reverse formation arrangement.
Bear in mind that for a safe position change, No. 4 must refer to No. 3, as indicated hereafter.



A.P. = ACCELERATION POINT: 250 KIAS, 1500 FT, BANK APPROX. 30°, $R_2 < R_1$

Figure 12-20. Joinup of the Two Elements of "Flight"

(b) Position in echelon formation. In echelon formation, No. 2 maintains the same position as in fingertip, No. 3 and No. 4 align on the same side as No. 2, that is all wingmen are on the same side with respect to the leader (fig. 12-21).
In this type of formation it is evident that if No. 2 does not maintain the correct position, No. 3 and above all No. 4 will face with difficulties.
The same will occur if No. 2 makes large power setting changes and maintain position with poor accuracy.

(c) Change from fingertip to echelon. The leader signals for echelon by dipping the wing in the desired direction. There are two possibilities for change from fingertip to echelon.
If the leader dips his wing in the direction of No. 2, No. 2 will maintain position: No. 3 and No. 4 will change, No. 3 to pass behind No. 2 and No. 4 behind No. 3 (fig. 12-22).
No. 3 starts changing moving back and down to provide adequate clearance from the lead element, then begins to cross to an echelon position on the wing of No.2. No.4 will maintain position on No.3 as long as No. 3 reaches alignment with No. 2, then will begin cross under to the new position on the wing of No. 3.
If the echelon signal is given toward the side of No. 3, No. 3 with No. 4 on his wing, moves out and back and slightly down to make room for No. 2.
No. 2 maintains position until the element has spread out, then executes a normal crossunder to take a position between the leader and No. 3 (fig. 12-23).

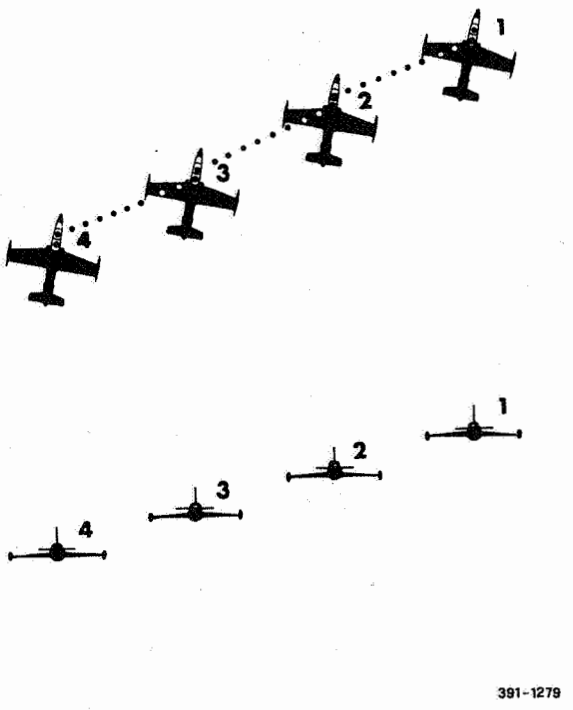


Figure 12-21. Echelon Formation of Flight

This change is called 'slot' because No. 2 "enters the slot" between No. 3 and the leader.

NOTE

If the leader wants No. 2 to change his position, he must avoid (at least during the first flights), to direct a change where No. 2 takes a slot position, but should direct a double change, that is a change to wingtip of No. 3 and No. 4 first, and then a change of No. 2 on the opposite side (fig. 12-24).

(7) Fingertip turns (fig. 12-25). Fingertip turns must always be flown with the wingman at the wingtip position, on the same plane as the leader and outside the turn.
With the so arranged formation the leader must avoid too sharp maneuver in consideration of the progressive changes of position and power (with respect to the horizontal plane of the leader) that the wingmen must fly in sequence.
Special care must be paid by the leader when he rolls out; this maneuver must in fact be flown smoothly and progressively to permit the last wingman to move down with regular changes.

(8) Echelon turns (fig. 12-26). Unless different specific directions, the echelon formation always performs echelon turns.
The echelon turns are flown in the same way as detailed in the chapter applicable to the two-ship formation.
Usually they are flown in echelon and, as for the two-ship formation, only prior special direction from the leader when at altitude. It is however possible to play an echelon turn also in fingertip formation. In this case the wingman (wingmen) outside the turn remain on the same plane as the leader while the wingman (wingmen) on the inside of the turn go down and align on the same wingplane as the leader.

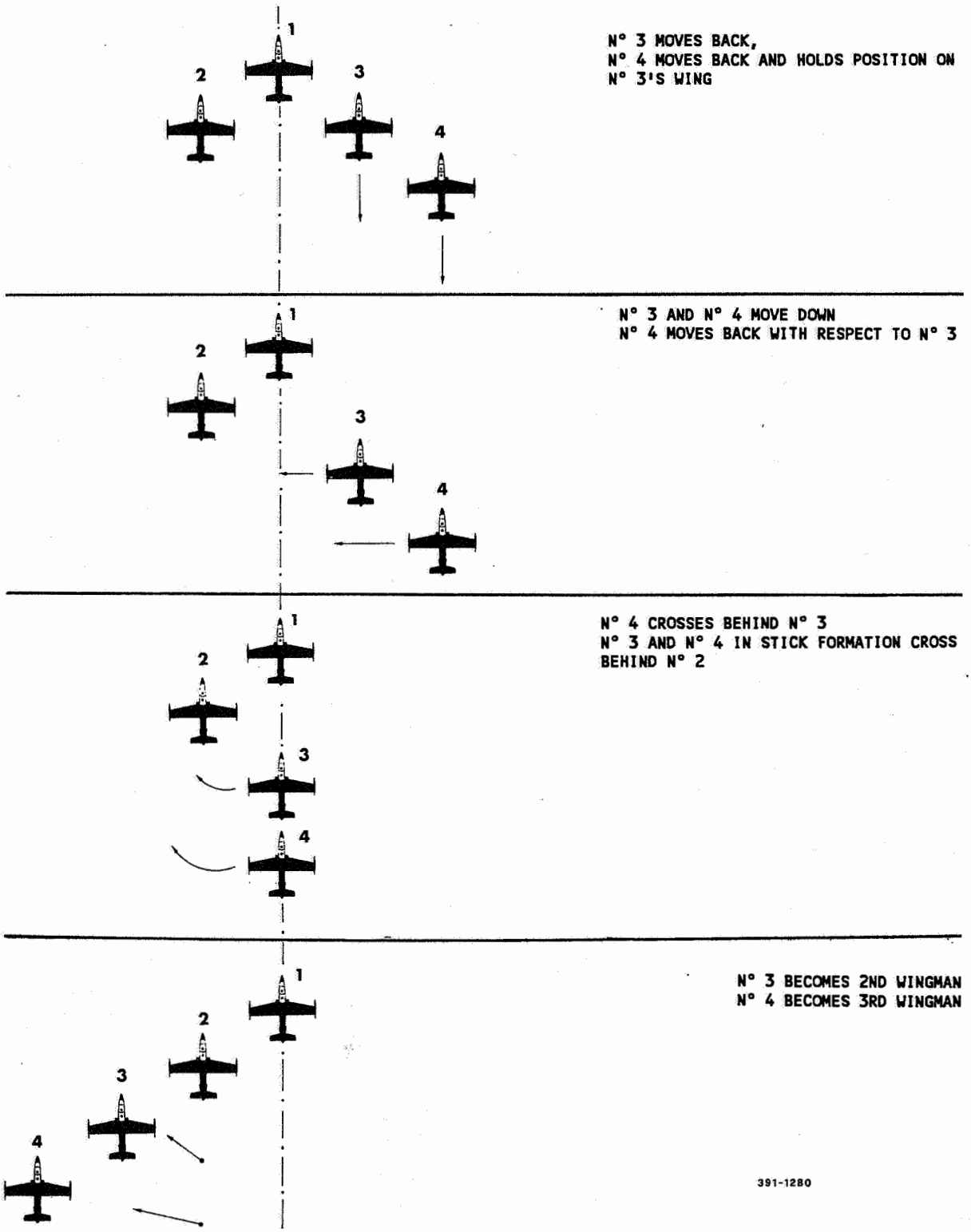


Figure 12-22. Change from Right Fingertip to Left Echelon

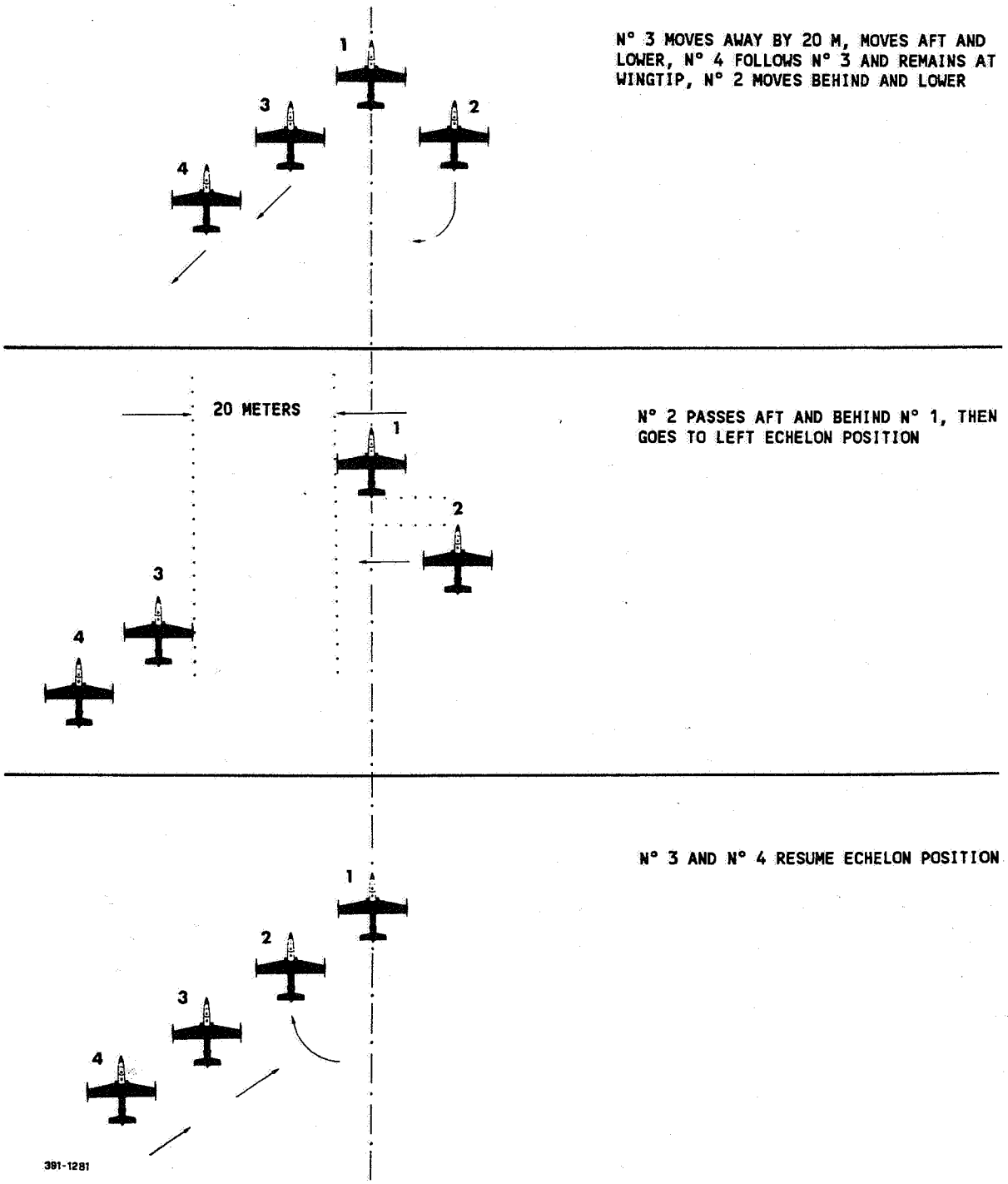

N° 3 MOVES AWAY BY 20 M, MOVES AFT AND LOWER, N° 4 FOLLOWS N° 3 AND REMAINS AT WINGTIP, N° 2 MOVES BEHIND AND LOWER
20 METERS
N° 2 PASSES AFT AND BEHIND N° 1, THEN GOES TO LEFT ECHELON POSITION
N° 3 AND N° 4 RESUME ECHELON POSITION
1
2
3
4
391-1281

Figure 12-23. Change to Echelon (Left)

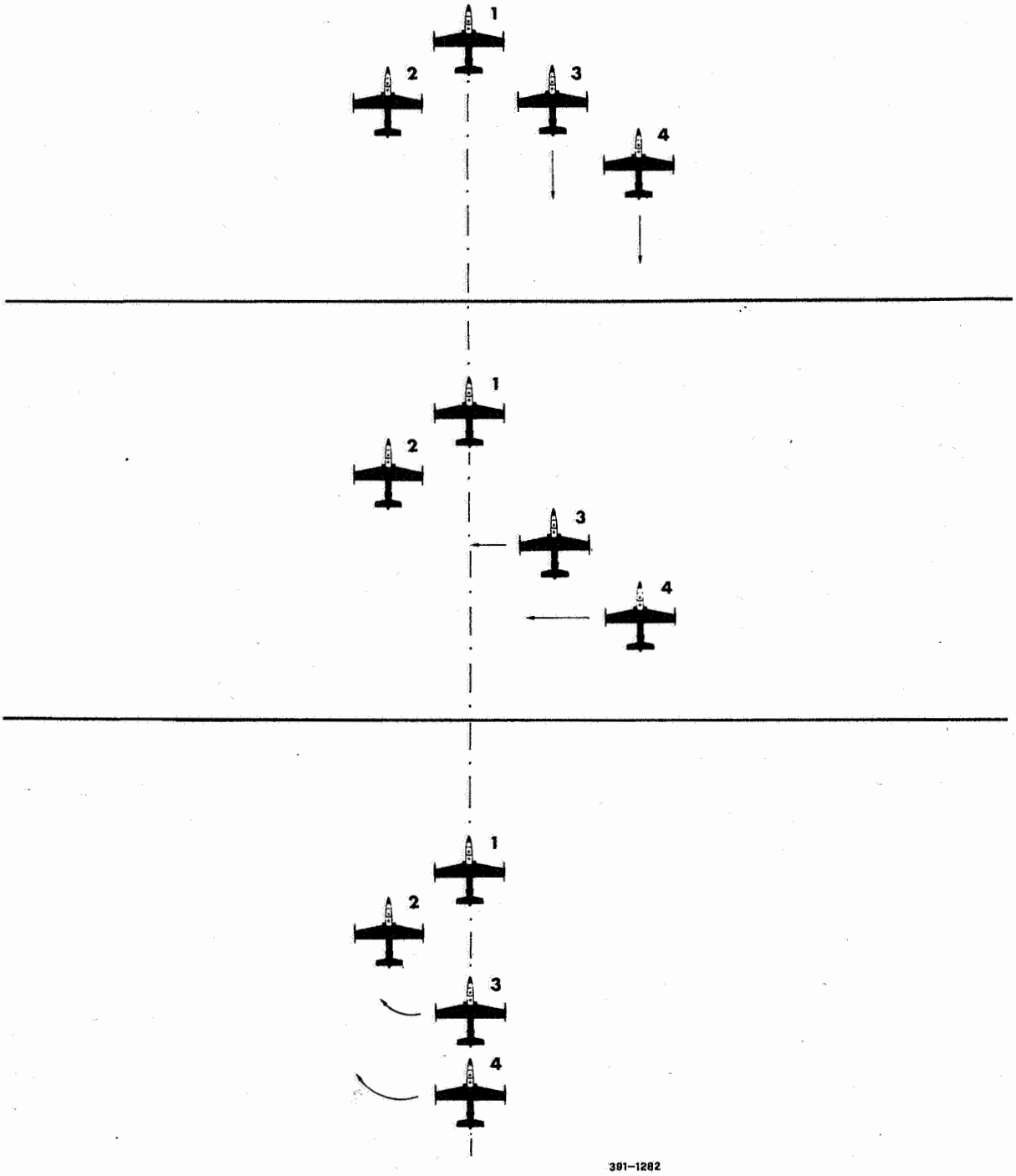


Figure 12-24. Double Change: First Phase from Right Fingertip to Left Echelon (Sheet 1 of 2)

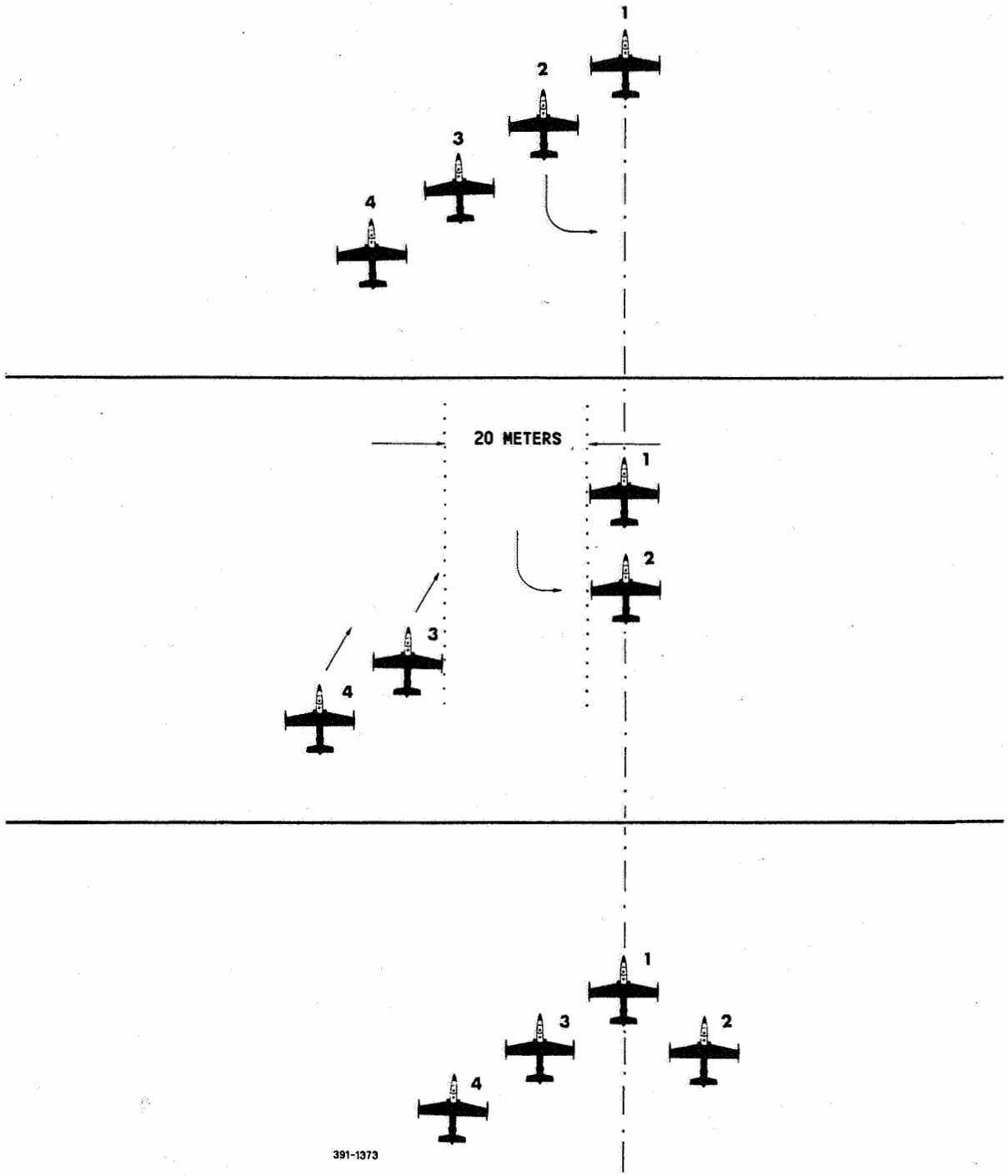


Figure 12-24. Double Change: Second Phase from Left Echelon to Left Fingertip (Sheet 2 of 2)

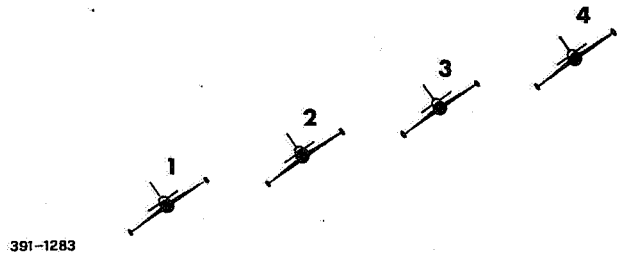


Figure 12-25. Fingertip Turn

During these turns it is essential that the wingmen do not fly in a too wide position not to overemphasize the normal trajectory and power setting changes that a correctly flown turn necessarily brings about.
To increase lateral separation in fact means to fly, in the order, greater and greater turn radii and be thus compelled to use proportionally high power settings.

(9) Change from echelon to fingertip. The leader dips the right wing (wingmen on the left side).
Formation changes as shown in figure 11-27.

(10) Break, extended and close trail, rejoin. The same procedures as detailed for the two-ship formation apply to these maneuvers. Usually the leader will call the pre-briefed engine RPM on the radio (usually 90%) and the JPT; these values will be acknowledged by No. 3. It is however best to add some special rules and advice:

- After break has been completed, all aircraft must be aligned on the wingtips inside the turn;

- It is best that the leader carries out the first wingover in the direction opposite to break to facilitate the wingmen when they want to resume position, and permit a possible rejoin

- Every wingman must do his best to maintain visual contact with the aircraft ahead. He must have the preceding aircraft in sight. If not so, he must inform of his situation and follow the directions of the leader.

- The signal of the leader that directs break of trail formation must be acknowledged by No. 2 and No. 3.

- The leader and No. 3 will reduce power setting by 2%, the wingmen will conversely retain the same power setting as at the beginning of the maneuver.

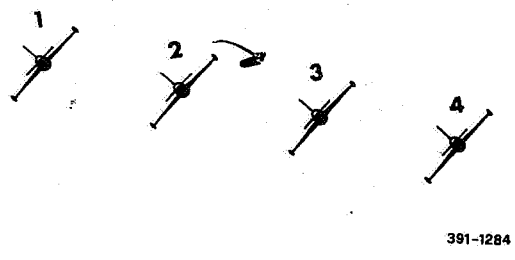


Figure 12-26. Echelon Turn

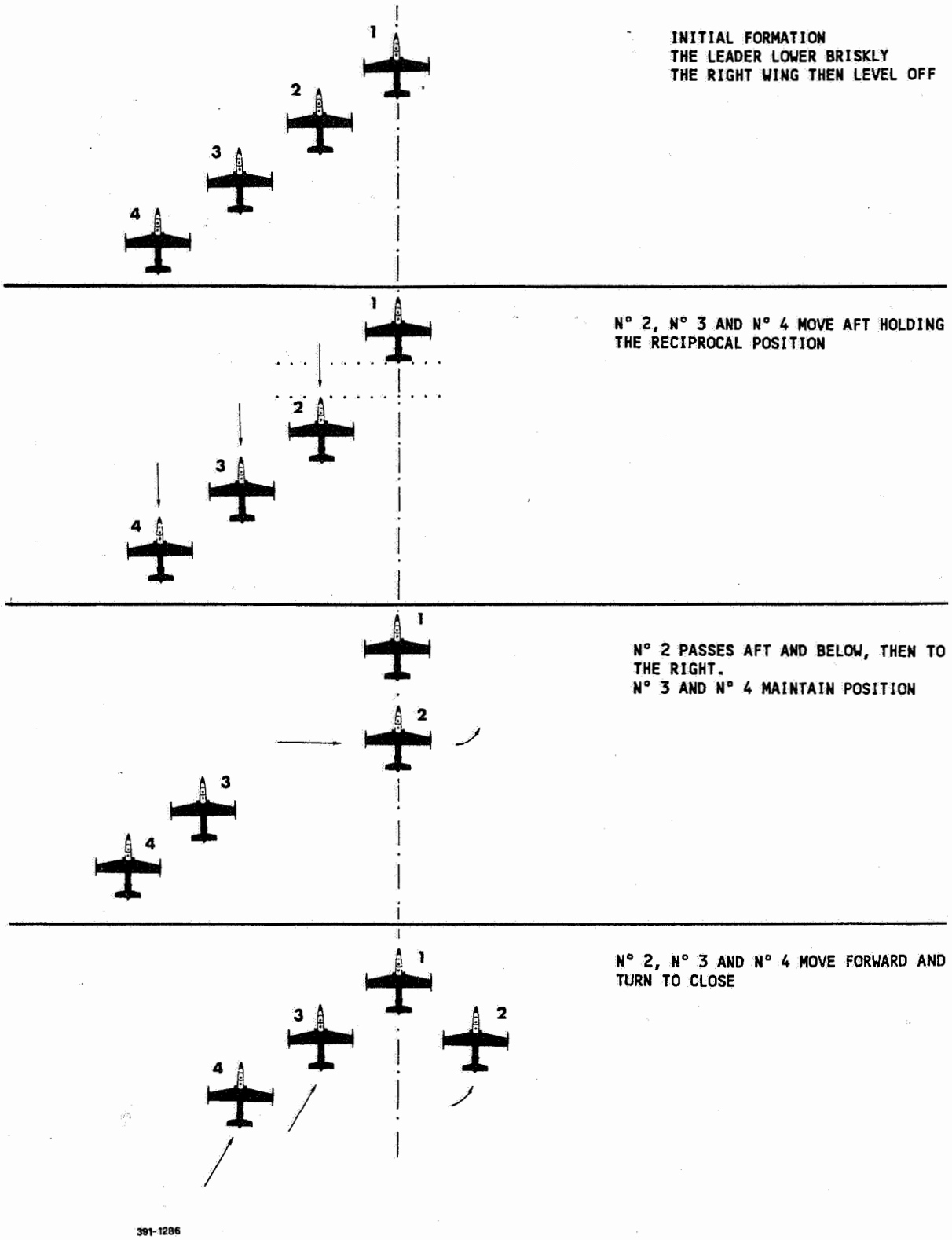

INITIAL FORMATION
THE LEADER LOWER BRISKLY
THE RIGHT WING THEN LEVEL OFF
N° 2, N° 3 AND N° 4 MOVE AFT HOLDING
THE RECIPROCAL POSITION
N° 2 PASSES AFT AND BELOW, THEN TO
THE RIGHT.
N° 3 AND N° 4 MAINTAIN POSITION
N° 2, N° 3 AND N° 4 MOVE FORWARD AND
TURN TO CLOSE
1
2
3
4
391-1286

Figure 12-27. Change from Left Echelon to Left Fingertip (Sheet 1 of 2)

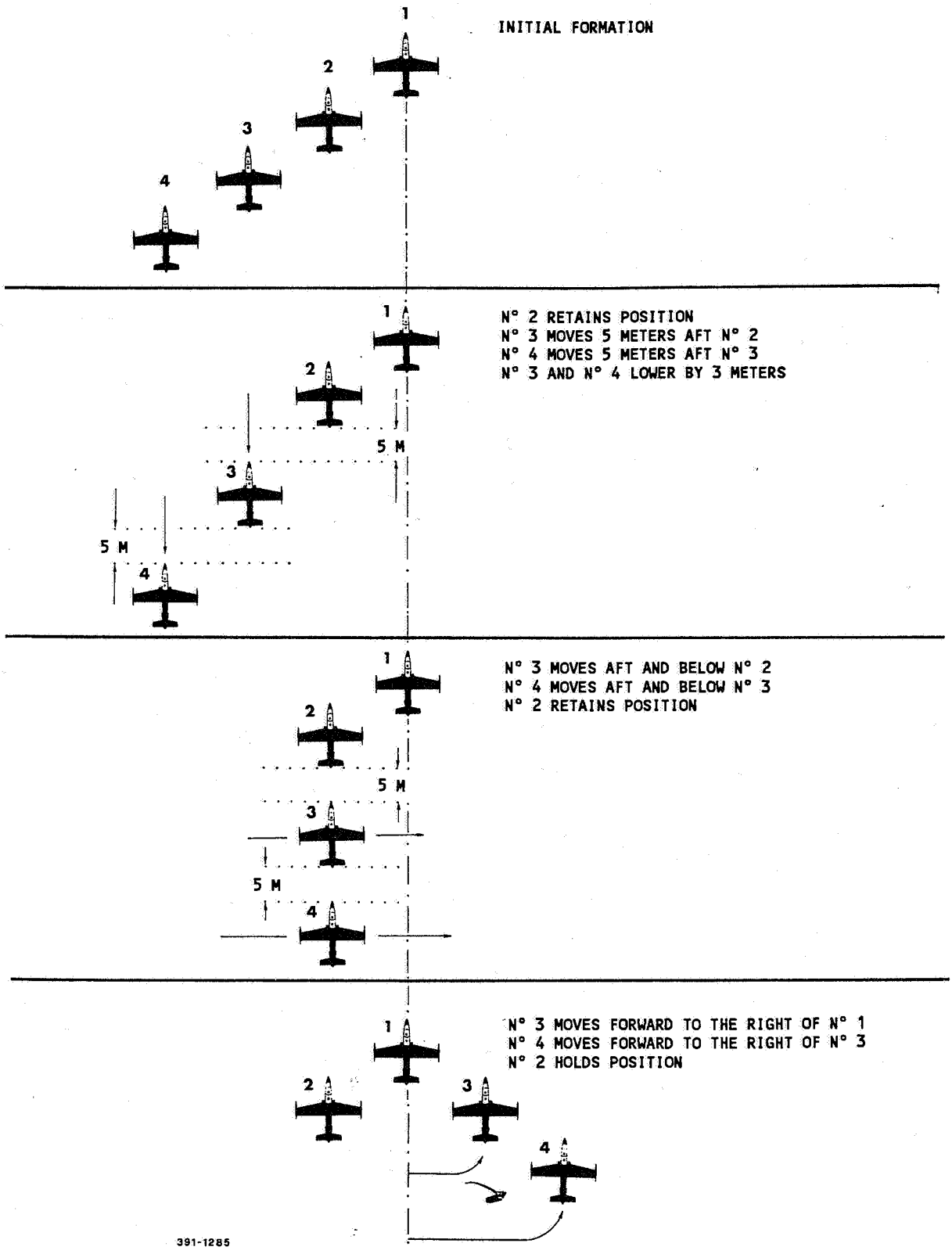

INITIAL FORMATION
1
2
3
4
N° 2 RETAINS POSITION
N° 3 MOVES 5 METERS AFT N° 2
N° 4 MOVES 5 METERS AFT N° 3
N° 3 AND N° 4 LOWER BY 3 METERS
5 M
5 M
N° 3 MOVES AFT AND BELOW N° 2
N° 4 MOVES AFT AND BELOW N° 3
N° 2 RETAINS POSITION
5 M
5 M
N° 3 MOVES FORWARD TO THE RIGHT OF N° 1
N° 4 MOVES FORWARD TO THE RIGHT OF N° 3
N° 2 HOLDS POSITION
391-1285

Figure 12-27. Change from Left Echelon to Right Fingertip (Sheet 2 of 2)

- When rejoin is completed, No. 2 must move inside the turn, and No.'s 3 and 4 outside the turn. No. 3 must start rejoin smoothly to wait for No. 4 which behaves as No. 2 with respect to the lead aircraft.

- When No. 4 has rejoined with No. 3, the second element will advance the throttle by the 2% RPM that was previously removed to start rejoin with the lead element. When closing on the lead element, No. 3 will direct change to his wingman.

(11) Visual descent. Visual descent is flown exactly as the descent in the two-ship formation. Both in planning and in the accomplishment of the maneuver, the leader should however bear in mind that a four-ship formation has less possibilities to maneuver.
Speedbrake extension must be directed through the radio.

(12) Instrument penetration. Once the formation has reached a position overhead a radio aid, has aligned on the basic holding pattern and at the EAT concurred upon with the Approach, the Flight breaks into two elements that become totally independent.
The element designated by the leader, usually element No. 2 (No. 3 and No. 4) starts direct penetration, while the lead element (No. 1 and No. 2) enters the holding pattern and holds for a time interval corresponding to the one specified for the successive descent.
From break, the two elements must complete the mission separately until landing. Therefore the considerations applicable to the two-ship formation descent apply.

CAUTION

Instrument penetration in four-ship formation is prohibited.

(13) Circuit. The considerations offered for the two-ship formation apply.
It is reminded that the formation must already be configured for break on leaving the initial point, that is the two aircraft must be in echelon. No. 2 and No. 3 must repeat the visual signals of the leader.

(14) Landing. Same as in two-ship formation.

d. Three-ship Formation

The three-ship formation is usually the result of an aircraft not taking-off or of an aborted take-off.
The leader, or the aircraft that according to briefed procedure had taken the lead, becomes No. 1 and designates his right wingman as No. 2 and left wingman as No. 3.
When the leader directs formation on the left wing, the left wingman (No. 3) maintains position, while the right wingman (No. 2) changes, thus taking echelon position with No. 3.
In a three-ship echelon, if No. 2 must take the lead, aircraft No. 1 moves away and aft thus taking the position of No. 2, and the No. 2 so becomes the leader.

NOTE

Of the two elements in the flight, if the leader of one element aborts take-off, the other element leader becomes the lead aircraft of the three-ship formation. The wingman, or the leader of the broken element becomes the last aircraft of the echelon (right or left) until positions are directed by the leader and ackowledged by all wingmen.

Instrument penetration in three-ship fingertip formation is permissible. They will change to echelon during final approach.

6. TACTICAL FORMATION

a. Introduction

Tactical formation is being taught to develop skills that will benefit the pilot in all phases of flying. The pilot will gain an insight into maintaining desired energy levels, especially in relation to other aircraft. Because of the objectives of these maneuvers and the way they are flown, they will increase the pilot's awareness of, and abilities in, clearing. The pilot will also be requested to maneuver the aircraft by outside references with minimum use of instruments.
Mastering tactical formation flying will enable the pilot to transition to the specific tactical formations applicable to the operational aircraft.
A tactical formation must possess the characteristics of maneuvrability, mutual support, cruise endurance and ease of control. Any tactical formation is a compromise. Direct in-trail formation provides excellent maneuvrability, but at the expense of visual flight coverage. On the other hand a line abreast formation allows for mutual visual coverage, but is hard to maneuver, i.e. as soon as lead turns the wingman is out of position. Having the wingmen spread in both the horizontal and vertical planes enhances visual search, maneuvrability and the wingman's relative energy.

b. Leading Tactical Formation

Once the leader has directed the formation to tactical, he must maintain a constant altitude and airspeed, or inform the flight of any changes. To help inexperienced wingmen, before directing to tactical, the leader may stabilize at cruise airspeed and power. This will allow flight members to note the power required to maintain the cruise airspeed.
Some techniques and principles that deserve consideration are: ALTITUDE: Medium altitudes 10 000 to 25 000 ft are best because airspeed is higher, acceleration capabilities are good and adequate G is available for maneuver.
CRUISE: The selected speed should provide both maneuvrability and good fuel flow. Leaders should realize that unnecessary power changes may cause the wingmen to arrive at bingo prematurely. A good cruise power setting for the MB-339A is 86% RPM.

c. Positions

Tactical formation can be flown in 2, 3 or 4 ship. Two-ship tactical formation is flown using positions of lead and No. 3. Four-ship tactical formation is depicted in figure 12-28. The visual signal to go into tactical is pointing motion towards the element's tactical position.
The element lead's position is 0° to 10° aft, 4000 to 6000 feet out, 500 feet low to 1500 feet high. When able, the element leader should work towards line abreast and high. The element's lateral and vertical position is dependent on such factors as the element's position relative to lead, the sun position, the presence of haze and other obstructions to visibility.
Proper separation from the lead element is not exact or rigid. Basically, if the wingman is too far out, he will have to make a considerable effort to monitor lead. If conversely he is too close he will not have time to react to the lead's turns.

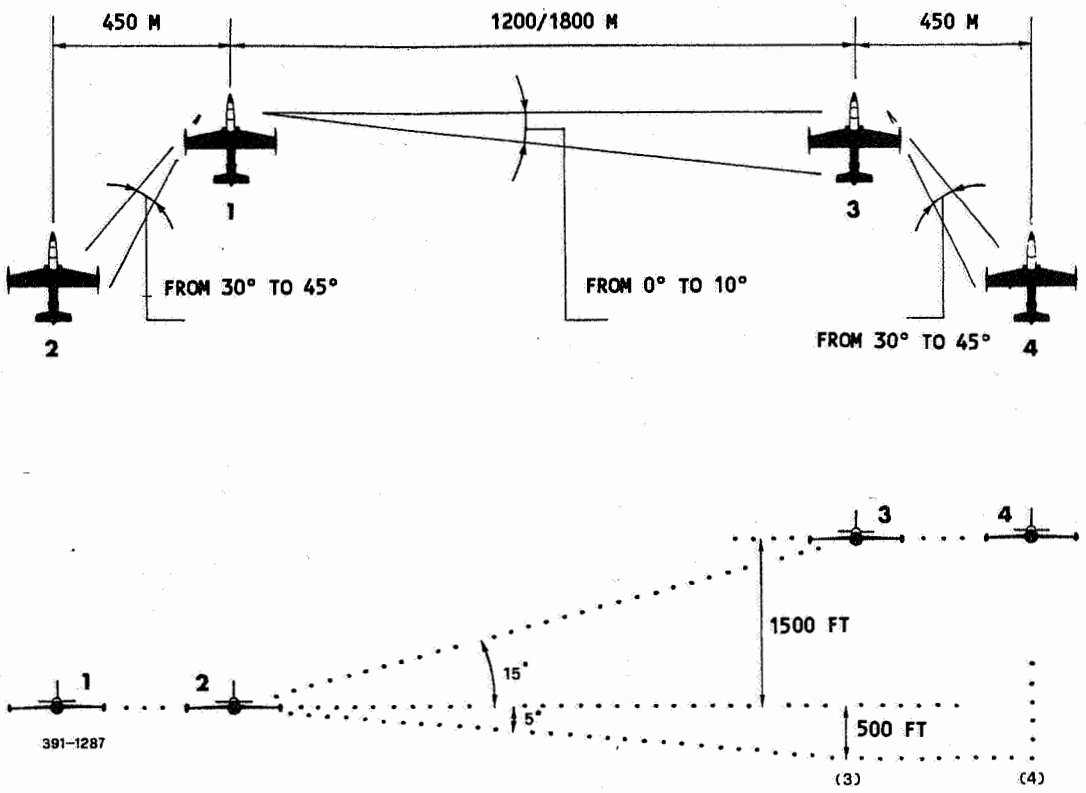


Figure 12-28. Tactical Formation

The proper spacing while learning tactical formation, is that which you can comfortably maintain during maneuvers, while clearing. The element leader must minimize power changes and maneuver freely to maintain a supportive position. If the element falls behind, it should unload for airspeed and then slowly climb back up to position after moving forward. If the element moves ahead, it should trade airspeed for altitude and then ease back into position, or use lateral movements, flying a series of S turns back to position.

The basic wingman position during tactical formation is -30° to 45° back, 1500 ft out, slightly low to slightly high. The wingman must minimize power changes and maneuver freely to maintain position on the outside of the formation. They should fly off their element lead but must know the position of all members of the formation at all times.

d. Tactical Turns

(1) Fluid turns. In fluid turns, lead will normally make heading changes in 90° increments using 45° of bank and maintaining airspeed. This allows flight members to plan their turns (fig. 12-29). The radio call for fluid turns is "(call sign) left/right turn".

(a) Turns into the element. Element lead (No. 3) shall start a turn in the same direction as lead. If insufficient altitude separation exists, start a gradual climb as you initiate the turn. Cross sufficiently above the lead element to allow room for No. 4 to cross under you. One technique is to use less bank than lead and maintain it until you cross over in front of lead. Another way is to initally match lead's bank and momentarily roll out of the turn or bank in the opposite direction to check lead's position.

To check the lead's element position as they approach, you should normally have 20° to 30° of the turn completed as lead passes your 6 o'clock position, depending upon the element's position at the start of the turn.

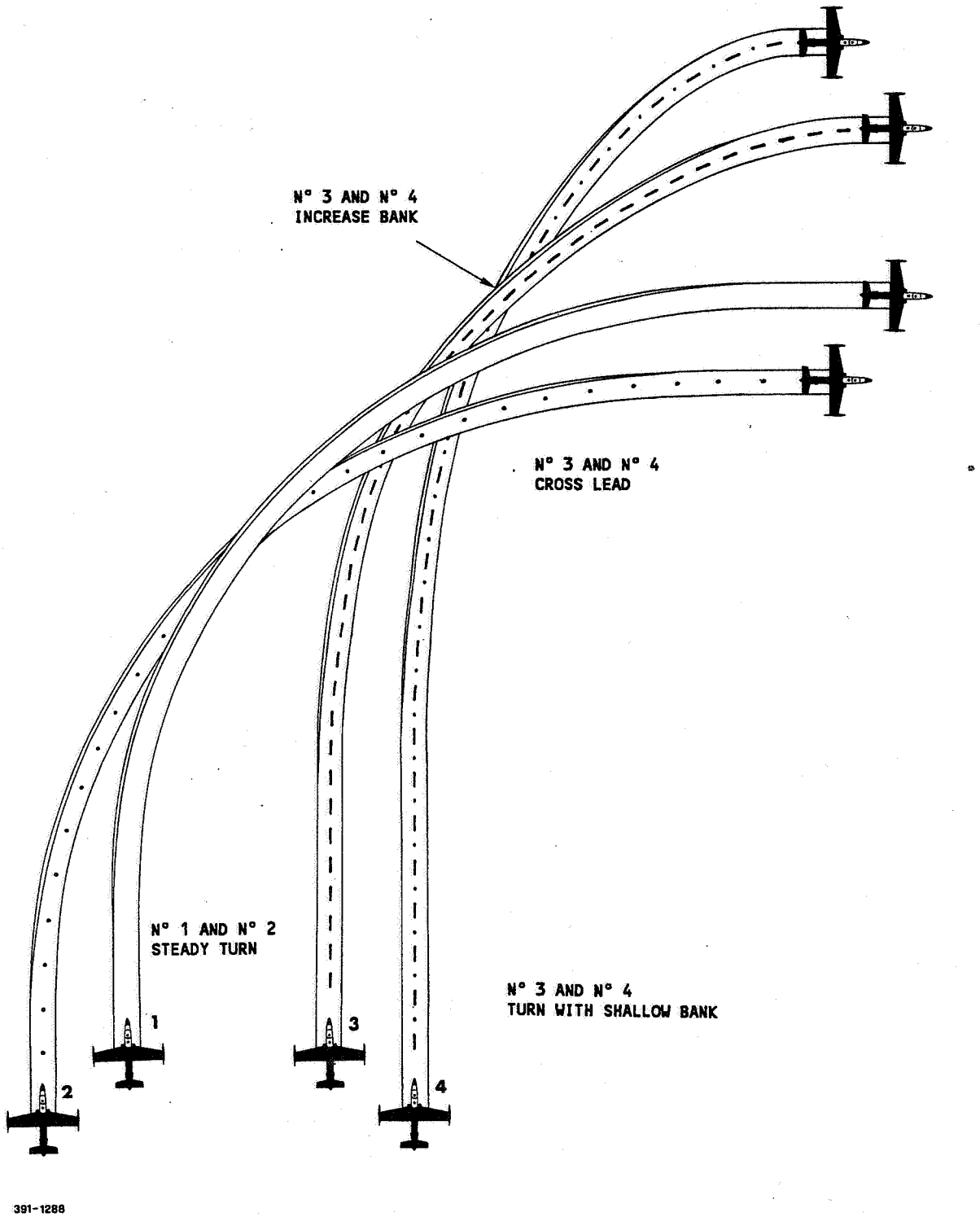


Figure 12-29. Fluid Turn

For example, if as the element lead, you were behind when the turn started, you may want to delay the cross, or if ahead, cross earlier. Once you have crossed over the lead, roll into approx. 60° of bank, lowering the nose to pick up airspeed, if applicable, and play the turn to assume proper spacing.
Use altitude to gain or reduce airspeed to arrive in the proper position as lead rolls out of the turn.

(b) Turns away from the element (fig. 12-30).
The element is immediately behind at the onset of the turn. You should roll into approx. 60° of bank and lower the nose slightly to gain energy in order to move to the inside of the turn behind lead. As the turn progresses, reduce bank to attain proper lateral spacing and trade excess airspeed for altitude as you approach the line abreast position.
Remember that airspeed correction can be made through use of the vertical while maintaining a fairly constant power setting.
In fluid turns (fig. 12-31), power and energy levels permitting, the wingmen should strive to remain on the side opposite the other element for as long as possible, in order to provide maximum clearing. Cross as your lead crosses the other element's 6 (or 12) o'clock. If insufficient power or energy is available, use cutoff geometry and time the crossunder so as to be in position as your element lead rolls wings level, and quickly reacquire the other element.

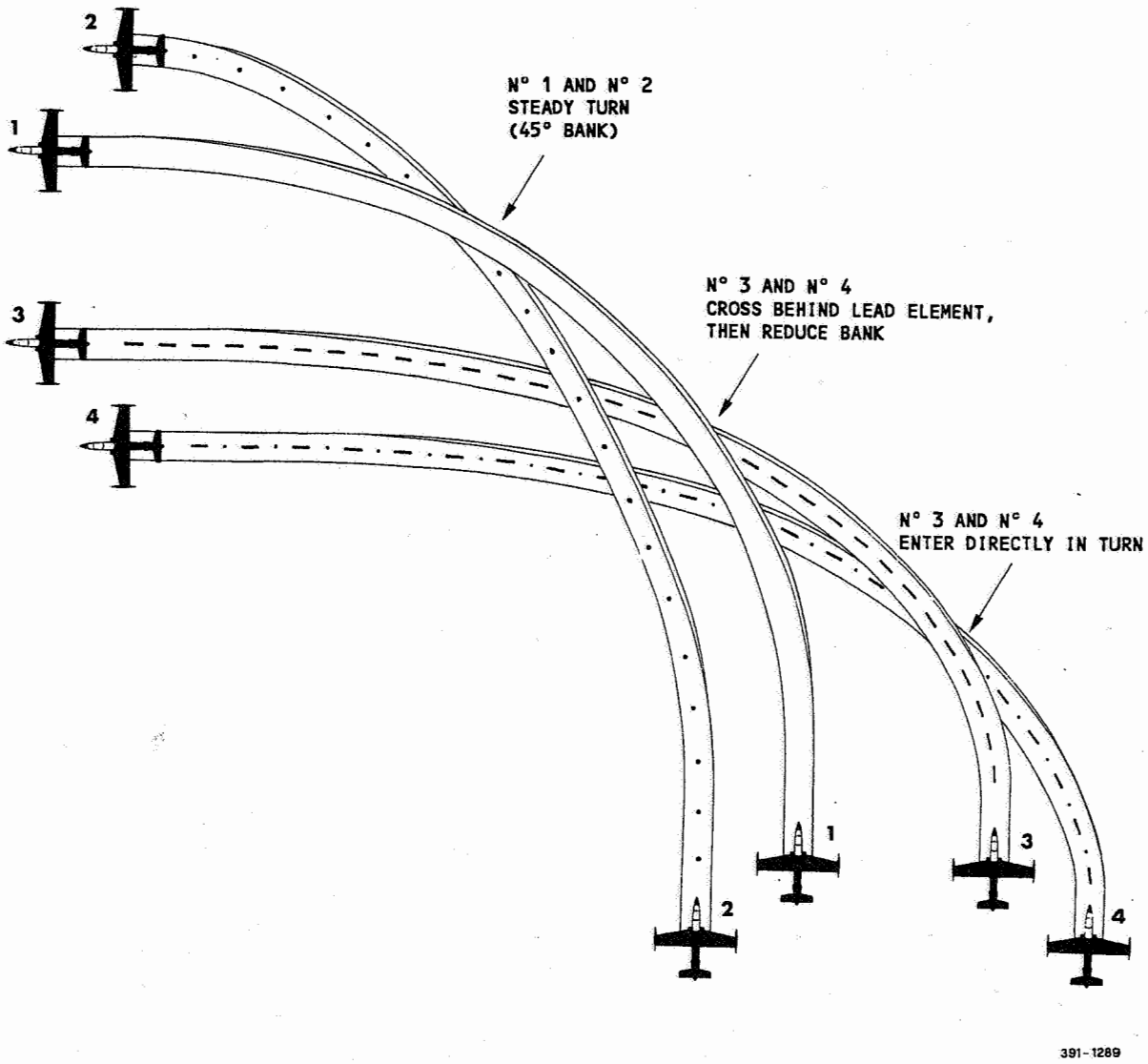


Figure 12-30. Fluid Turn Away from Element

As No. 4, use caution not to cross too low under your element lead or you will interfere with the lead element.
Summary:
When turned into, the element should initially use a shallow bank and climb as required, then steepen the bank and descend as required. When turned away from, it will initially use a steeper bank and descend, then shallow out the bank and climb. Throughout all these maneuvers, as the element leader, make only small power changes, or, if possible, none at all. You will have a wingman, and it is likely the wingman has little power advantage.

(2) Delayed-90° turns (fig. 12-32). The delayed-90° is used to turn the formation 90° in minimum time. It is preferred over a fluid turn because visual coverage is only slightly degraded since time in the turn is reduced.
The radio call for a delayed-90° is "(call sign), 90° left/right ... now". A slight pause is usually made before the command of execution to allow the wingmen time to prepare for the turn.

(a) Turns into the element. As the lead begins the turn, No. 3 continues straight ahead. When lead has turned approx. 45°, the rate of movement of the nose of the aircraft will become very evident. At this time, No. 3 begins a 90° turn with 96% RPM, a load factor of approx. 3 to 4 G and 0.6 AOA, in the same direction.

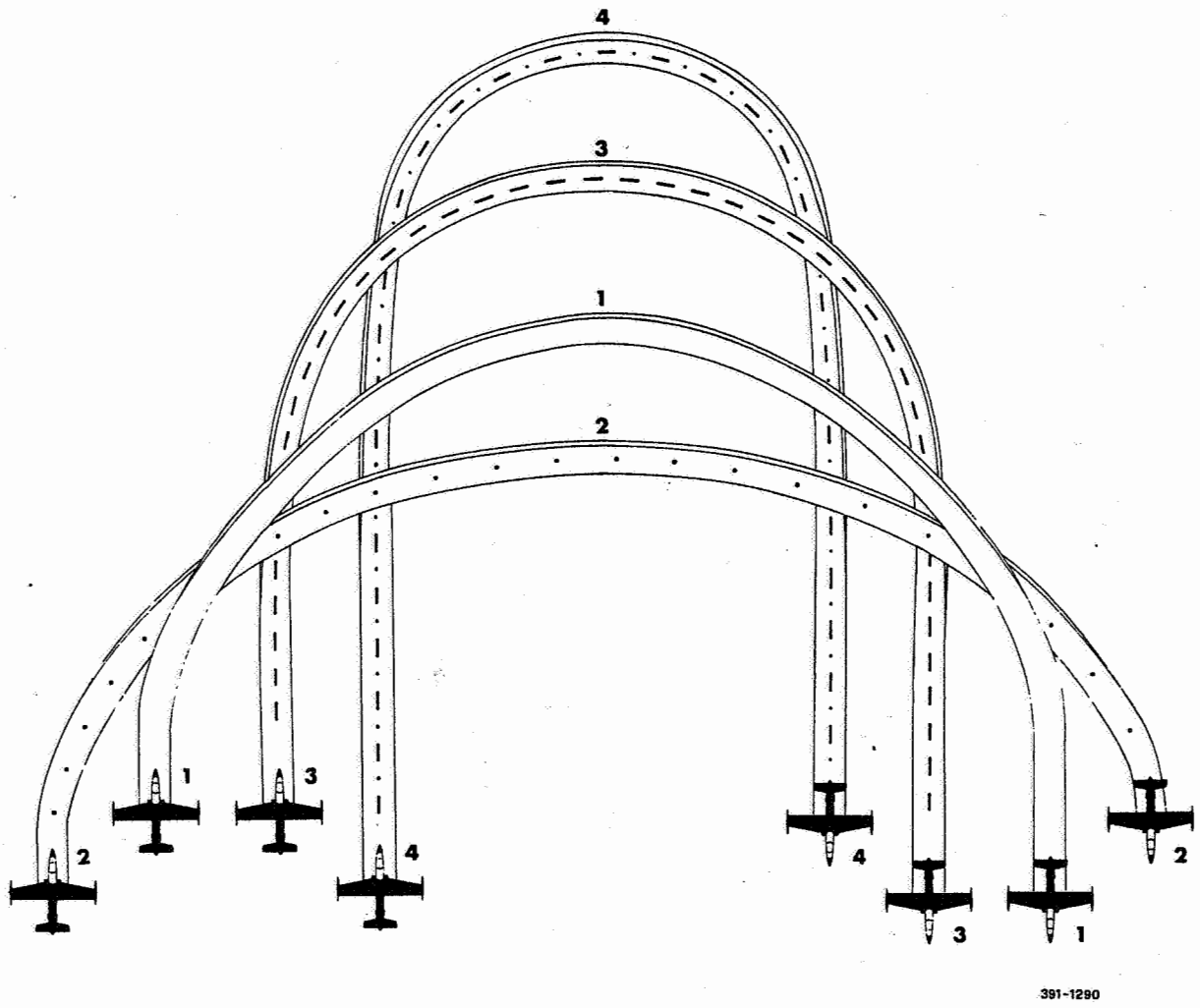


Figure 12-31. 90°/180° Fluid Turn

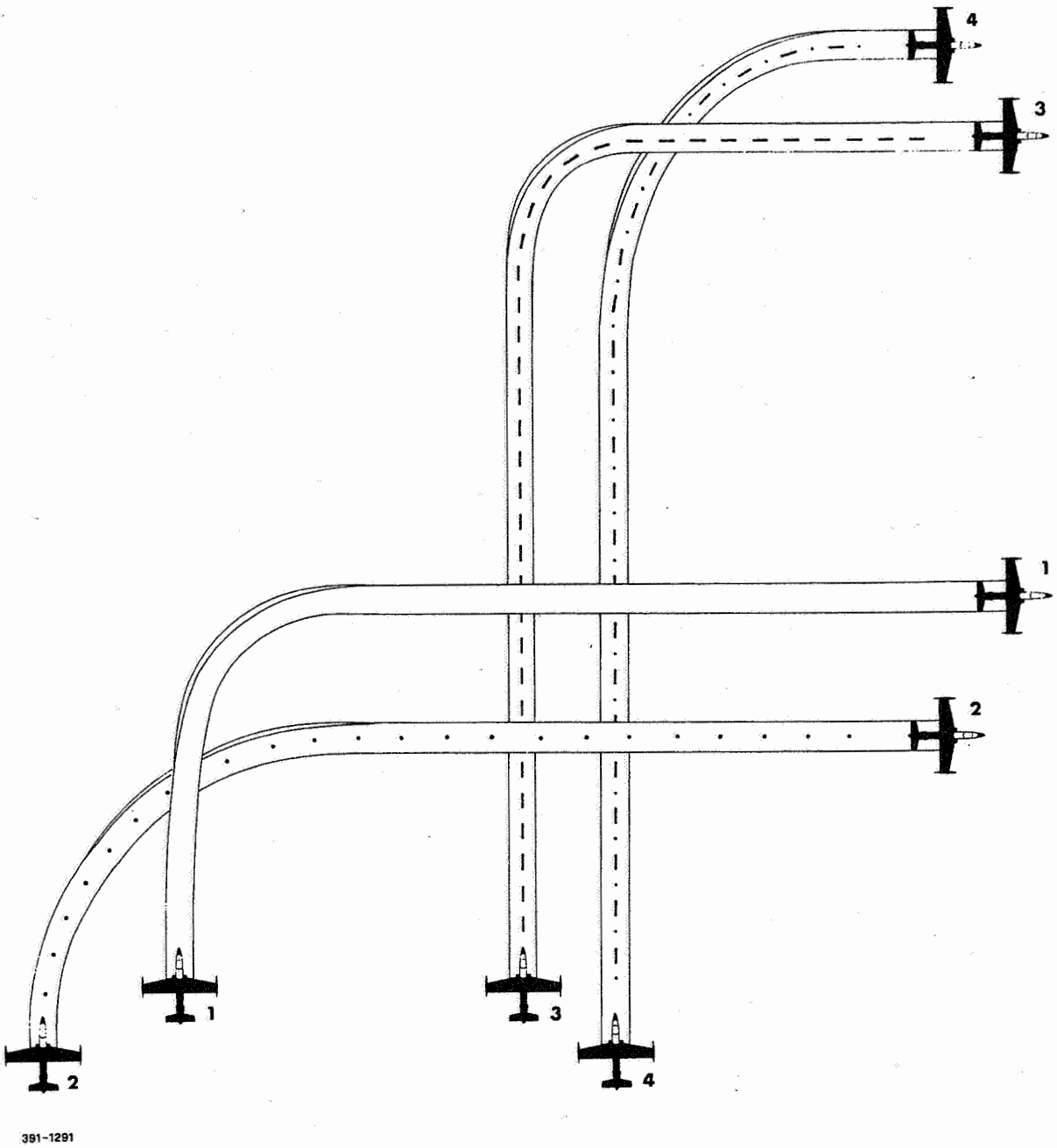


Figure 12-32. Delay - 90°

The timing of No. 3's turn may be varied somewhat depending on altitude, TAS and the element's position. Generally, if the element is close, No. 3 should turn later; if far apart, earlier.
If the element was behind, they should turn earlier; if ahead, later. During the last half of the turn No. 3 should monitor lead and play the turn to roll out in position.

(b) Turns away from the element. No. 3 begins the turn on the command "Now", exactly as described above for lead. Before turning, No. 3 must note a ground reference for heading to determine the roll out point. Lead delays and flies the turn as described above for No. 3. Once established on the new heading, lead stops flying off of No. 3.

Summary.
As a guide, if you are looking, (clearing the other element), in the direction called, or if the turn will be away from your element; you turn first. Use 96% RPM starting the turn and reduce power rolling out.
As the element leader begins the turn, the wingman must begin to take advantage of cutoff to develop closure. Use the maneuvering cone but continue to close, planning to cross behind lead just prior to roll out. The timing of the crossunder and lateral drift rate will vary with your energy and closure advantage. If slow and behind, try to use more cutoff, cross later, and with a slower drift rate. If fast and closing rapidly, cross earlier with a faster drift rate. The objective is to be in position when your element lead rolls wings level, not after lead rolls out.

(c) Wingmen (Numbers two of four) techniques. Immediately maneuver in the cone towards the inside of the turn and slightly lower than your element lead as No. 3 starts the turn. Move quickly to the inside; using cutoff to close toward your leader. As your lead rolls out, move to proper position.
Summary.

During any delayed-90° turn, each wingman will cross on time to stay opposite the other element. On a turn into you, close with cutoff and plan your cross. On turns away, bid quickly toward the inside and slightly low, cross early, and adjust toward final position.

(3) Weaves. A weave may be employed when cruising in tactical formation on a constant course or when it is desirable to vary headings so as to provide 6 o'clock coverage. There is no necessity for the elements to cross directly over each other or at right angles: all that is desired is for the two elements to maintain weaving random flight paths and mutual visual coverage.
Weaves are normally flown with 45° of bank (fig. 12-33). Lead begins a turn and monitors the element to determine when to roll out of the turn and when to initiate the turn back to reference heading.
No. 3 plans the turn around lead to arrive in proper position at the end of the weave. No. 3 can correct for fore and aft positioning by flying a wider S turn if ahead or close, or by making smaller heading changes if behind or wide.

(4) Check turns. Check turns are used for minor heading changes, for navigation, or to return to a reference heading. They are usually less than 30° of turn and performed at 30° to 45° of bank.
Check turns can also be used to align the flight if the element is forward or aft of normal position. For example, if the element has proper vertical spacing, but is behind, a check turn toward the element will immediately reposition it.

(5) Rejoins

(a) Straight ahead rejoins. Unlike normal straight ahead rejoins where flight members join from a trail position, tactical straight ahead joins up begin with flight members spread laterally. Each member must join on the side of lead from which the joinup is initiated. DO NOT cross lead's 6 o' clock position at any time during the rejoin. When the rejoin is directed, initiate a move to a position just aft of lead. For the element members, this move is a descending S turn to loose altitude and close lateral spacing. It causes you to travel a greater distance than the lead which dissipates your altitude advantage without necessarily reducing power or airspeed. The turn places you in a normal straight ahead rejoin position, slightly behind lead with an airspeed advantage. The initial move towards lead should not be so aggressive that you deplete all your energy or overshoot lead's 6 o'clock position. No. 4 should stay in a maneuvering position behind No. 3 but with sufficient spacing to effect a separate rejoin. Again, during a straight ahead rejoin, you must remain on your side of lead at all times.

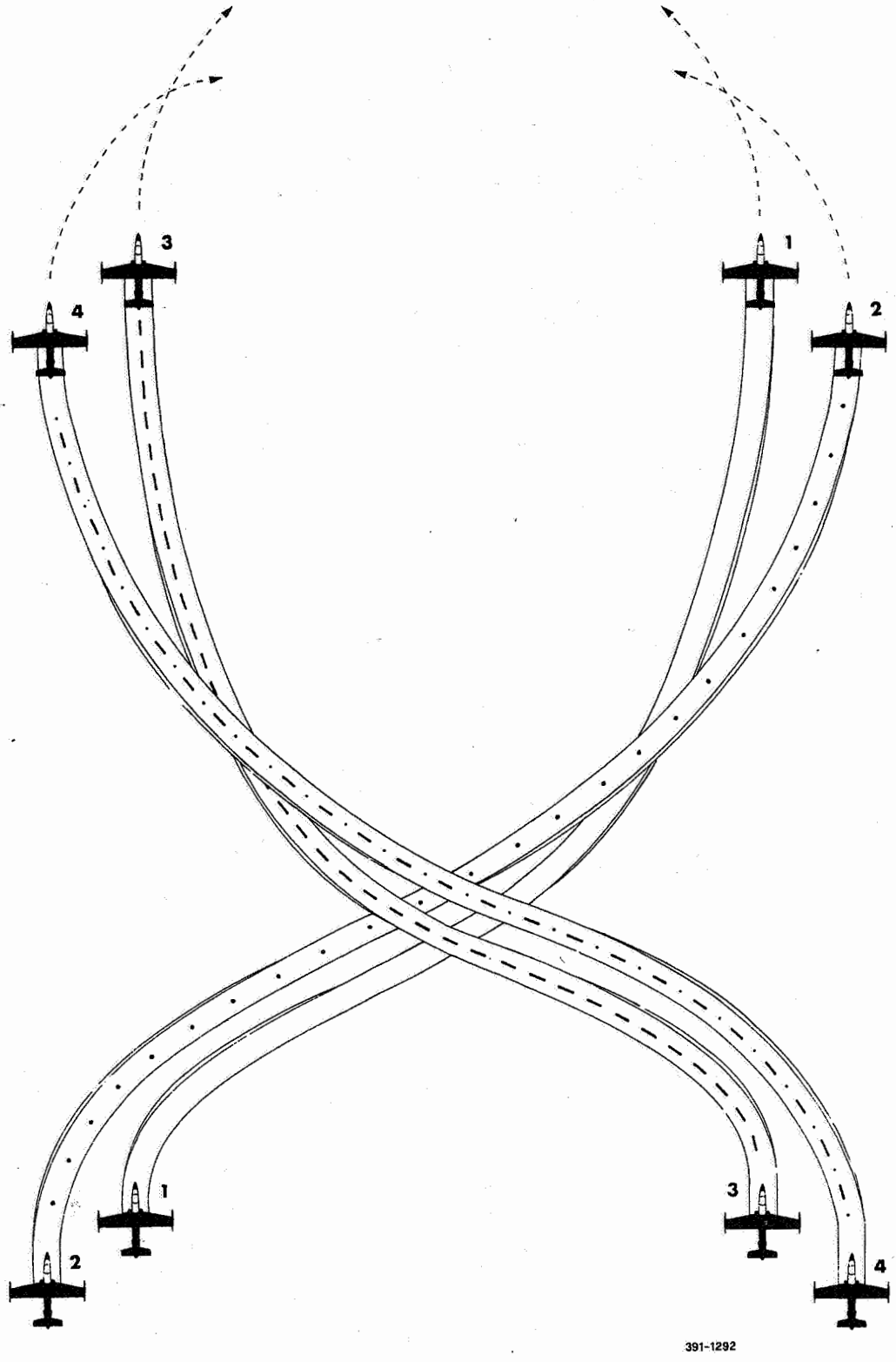


Figure 12-33. Weave

(b) Turning rejoins

- Turns away from the element.

The element is behind from the onset and should move to the inside of the turn to facilitate closure and seek a normal rejoin line. No. 4 should follow No. 3 with sufficient spacing to make No.4's own rejoin in sequence. Once on an acceptable line, the element members make a normal rejoin to the outside of the turn. No. 2 needs only initiate a normal rejoin.

- Turns into the element.

No. 2 should move directly to the inside wing of lead. There is no need for No. 2 to go deep inside the turn to get on the normal rejoin line. The element is positioned ahead of the normal rejoin line from the beginning. As lead turns into the element the rejoin line is shifted further behind their position. Therefore, the element should maneuver outside of the turn and reverse toward inside in order to achieve a position on the line. During the maneuver to the outside the element members should climb as necessary to avoid No. 1 and No. 2. Once clear of lead element they can begin the reverse and descend back down to the rejoin line. As in the other rejoins No. 4 should follow No. 3 but with enough spacing to effect No. 4's own separate rejoin in sequence.

PART FOUR - CHAPTER XIII

NIGHT FLYING

TABLE OF CONTENTS

Title	Page
Introduction	13-1
Vision at Night	13-1
Ground Procedures	13-2
Take-Off	13-3
Night Pattern and Landings	13-4
Night Navigation	13-5
Night Two-Ship Formation Flying	13-7

1. INTRODUCTION

a. Definitions and Rules

Night flying is defined as the flight (or portion thereof) that is flown in the interval between half an hour after sunset and half an hour before sunrise according to the data given in the aeronautical almanac of the considered locality.
Night flying practice is flown when the student pilots have attained a good training level. In particular, it is carried out after the student pilot has completed training in instrument flying and visual flying.
In compliance with the air traffic regulations, night flying is considered an instrument flying. An IFR flight plan must always be prepared for a night flight.

b. Conduct of the Flight

As far as aircraft piloting is concerned, night flying is a combination of visual flying and instrument flying.
Therefore, to fly at night, it is necessary to refer also to chapter X of this manual and to publication PI AD-03-39A "Instrument Flying and Navigation Manual".

2. VISION AT NIGHT

a. Recommendations

During night flying it is essential to bear in mind some recommendations aimed at improving vision at night.
To have the eye getting the poor ambient light, the pupil expands, while it contracts in normal or bright lighting conditions.
Since pupil adaptation to ambient lighting takes a little time, it is essential that the pilot has some time available to accustom to darkness. Therefore he must avoid glancing at bright spots.
Besides, smoking and alcoholic beverages sharply reduce the eye adaptation capability.
It is conversely advisable to take foods with a high sugar content.

(1) Internal lighting should permit an easy reading of the instrument and avoid undue tiring of the eyes and unclear outside vision.
It is advisable to adjust lights to the minimum necessary to read the instruments to avoid false sensations when the pilot changes from instrument reading to the observation of the outside environment.

(2) High cirrus clouds, saint Elmo's fires, the use of anti-collision or landing lights in bad weather may all contribute in disorienting the pilot. If flying inside clouds, switch off the anti-collision or landing lights and concentrate on instruments.

(3) Correct oxygen supply should be checked more frequently in flight, as the first symptom of hypoxia is a decrease in the visual effectiveness.

(4) It must be borne in mind that lighted visual references on the ground are visible from quite a large distance, and this may lead to an incorrect evaluation of their actual distance.

3. GROUND PROCEDURES

a. Briefing

Night flying, be it on the traffic pattern or including a navigation leg covered by an IFR flight plan, should usually be preceded by a general briefing. All aircrews and the members of the concerned ground activities should take part in it (coordination officer, or flight commander, meteo officer, TWR-APP controller, Safety of Flight officer, wing physician, etc.).
The briefing, that must be deep-going and exhaustive, should deal with any details of the mission (airwork), with special reference to the procedures that it is necessary to apply or be knowledgeable of in case deviations from the planned flight should be necessary.
It must be complete with all information concerning the global flight development and in particular include a thorough and complete comment of all possible emergencies inherent in the type of mission to perform.

b. Equipment

In addition to the normal flight equipment, it is essential to carry on board a three-colour flashlight to be connected to the life jacket. This flashlight is kept at the Equipment Room and the pilot should pick it up there before flight. The flashlight is a very important item because it may be the only means of checking the instruments and maps in case of total electrical failure, of indicating possible emergencies in case of radio failure during formation flying and of signalling on the ground. In the case of radio failure, remember that it is also possible to use the two spotlights available in the cockpit.

c. Checks

In addition to the normal daytime exterior checks detailed in the Checklist, accomplish the following:
LIGHTS panel on the right console:

(1) Interior lights:

- "CONSOLE", i.e, the internal lighting of control panels on the consoles, centerstand and instrument panel.

- "INST", that is internal illumination of instrument dials.

- "FLOOD", that is white light lamps that illuminate the cockpit from the side up. Do not mistake them for the white or red spotlights.

(2) Exterior lighting:

- "NAV" navigation lights: switch on to BRIGHT-FLASH unless otherwise directed

- "BCN" anti-collision light

(3) Besides, shortly check landing and taxi lights for correct operation

(4) "WARN" warning lights may be selected at "DIM" (dimmed) since they are always associated with the "MASTER CAUTION" light.
It is recommended to carefully read the FM, Section I.

(5) Some control panels have an independent and self contained light dimming circuit. Therefore check the "UHF" frequency indicator panel and the "RNAV" display and control panel; adjust their brightness as required.

(6) The spotlights, two for each pilot, should be used only when needed and in emergency situations. Check the lights for proper operation and then switch them off.

d. Engine Start Up

Start up engine at the pre-briefed time after receiving the clearance from the tower; switch on the anti-collision light before engine start up to indicate that the engine is about to be started.
After engine start up, switch on the navigation lights to "BRIGHT" and "FLASH".

e. Radio Procedures

The radio procedures applicable to night flying are substantially identical to those used for daytime flying. However adhere to the instructions received from the Air Traffic Control activity of the airport (s) on which you operate.

f. Taxiing

Taxi will be on the centerline of the taxiway. The taxi light may be used in case of difficulties or doubts as to the path to follow. Bear in mind that judgement of speed is poorer by night and that tendency is to taxi too fast.
As the eyes get used to darkness, reduce the brightness of the cockpit lights and avoid glancing at bright spots.
Taxi at a safe distance from the aircraft ahead (100 m or two taxiway side lights).

4. TAKE-OFF

See the FM, Section II.
Take-off is flown visually but following the instrument procedures.

a. Lineup

Line up in the center of the runway after receiving clearance from the tower. Carry out all checks as envisaged for daytime flying.

b. Take-off Ground Run

At night, the take-off run and take-off are generally flown with a technique that is a combination of visual flying and instrument flying.

In particular, to hold direction during the ground run, reference will be made to the runway centerline and side lights.

c. Lift-Off

At 90 KIAS raise the aircraft nose to 7° (miniature aircraft tangent to the 5° dot to climb on the ADI).
When 100 KIAS are attained with a 7° nose-up attitude, the aircraft will lift-off spontaneously.
Maintain roll and pitch attitudes mainly on the ADI (look outside and inside). After lift-off and as soon as the runway lights disappear, it is necessary to overcome the momentary disorientation caused by sudden darkness. In particular in this interval, it is essential that instruments be more closely checked to avoid significant piloting errors.
When the vertical velocity indicator indicates a climb and the altimeter an altitude gain, retract the landing gear and the landing light. At 120 KIAS retract the flaps.

d. Acceleration to Leave the Pattern

Just after lift-off, maintain the take-off attitude and subsequently, at a safe altitude and an airspeed of 120 KIAS, carry out the prescribed checks:

- On rotation and lift-off, check and hold approx. 8° on the ADI.

- Maintain the direction and attitude permitting the acceleration point to be reached at an altitude of 1500 ft and a IAS of 250 or 225 kt, as a function of the aircraft drag index.

e. Acceleration to Hold Pattern

After lift-off, maintain an attitude permitting the airspeed of 230 KIAS to be attained at 1100 ft. At this altitude, act on the control stick and retard the throttle to approx. 82% RPM in order to level-off at 1500 ft with a IAS of 250 kt.

5. NIGHT PATTERN AND LANDINGS

a. Pattern

- The path and parameters for night pattern are the same as during daytime.

- The procedure to follow to hold pattern after take-off is also identical to the one flown in daytime; piloting will be mainly visual. The required evaluation of instrument readings will however be made.

- Report to TWR when abeam the TWR on the downwind leg, by calling "on downwind".

b. Overhead and Landing

- Overhead, base turn and final are flown as in daytime.

- It is pointed out that the base turn must not be completed at an altitude lower than 500 ft, for optimal roll-out on final.

- Once aligned with the runway, flash the taxi light to permit the runway mobile radio station to check that landing gear is down and locked.

- After flashing the taxi light, switch on the landing light.

- Touch-down must be in the center of the runway. In this phase it is best to look forward and observe the row of lights that is the farthest away on the runway side. It is thus easier to perceive correct direction and distance from the ground on landing.

c. Touch and Go

- The touch and go procedure at night is the same as the daytime procedure, exception made for the turn, which is not flown irrespective of the altitude.

- After engine reopening, avoid taking excessively nose-up or flat attitudes; check the attitude on the ADI.

- Switch off the landing light as soon as possible

6. NIGHT NAVIGATION

a. Climb and Descent

- The night flights envisaging a climb to altitude are all radio-aided navigation flights. Climbs will be as envisaged for instrument departure.

- To fly descent, the penetration procedure will be adopted. Level-off procedures, both after climb and descent are the same as during instrument flying.
See the "Instrument Flying and Navigation Manual" PI AD-03-39A.

b. Radio Aided Navigation at Night

- Night navigation must always be flown according to an IFR flight plan. Dead reckoning and instrument navigation principles are concurrently enforced during this navigation.
Night navigation in fact requires a preparation on the ground and compliance with the IFR in flight, as the radio aided navigation, but also permits, if weather conditions are favourable, to fly on ground references, as during dead reckoning navigation.

- What already specified for radio-aided IFR navigation applies to ground maneuvers, radio procedures and air traffic regulations. As to piloting, both radio aids and ground references will be used.

- High cirrus clouds, Saint Elmo's fires, anti-collision lights or landing light on when flying in rain, may contribute to pilot's disorientation.

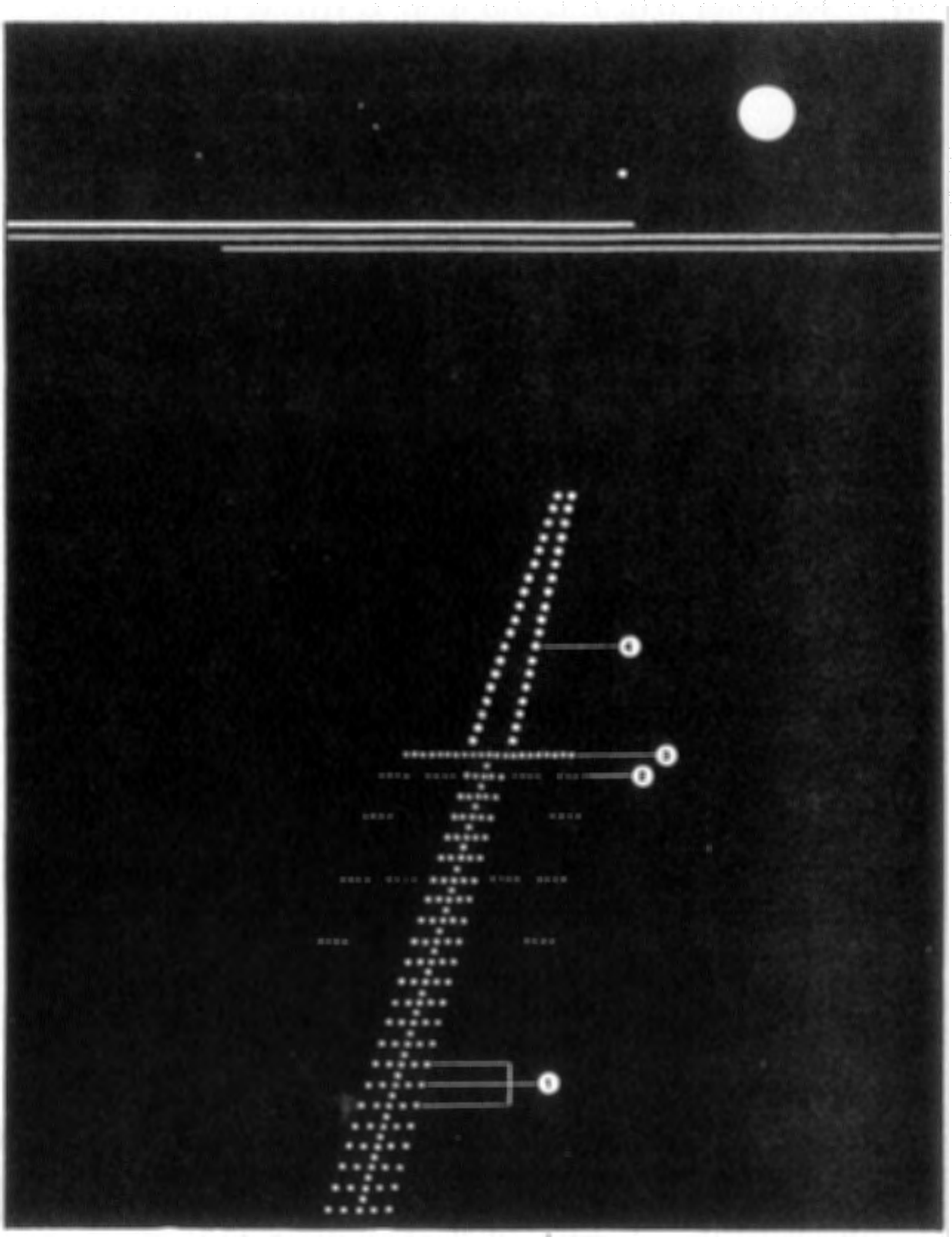
- When flying in cloud or rain, switch off the ant-collision or landing lights and concentrate in piloting on the airborne instruments.

c. Night Approach

Night navigation flights usually include a climb to medium or high altitude, a standard level flight leg, an instrument approach, a touch and go and some patterns.
Approach will be flown according to the instrument procedures, as indicated in publication PI AD-03-39A.

d. Aerodrome Lighting (fig. 13-1)

- Note that the air base lighting systems are not fully standardized and that the most remarkable difference between one airfield and the other is the arrangement of the approach lights.



1. APPROACH LIGHTS - FLASHING IN SEQUENCE
2. RED THRESHOLD LIGHTS
3. GREEN THRESHOLD LIGHTS
4. RUNWAY LIGHTS

Figure 13-1. Illumination of Glide Path and Runmay

- The approach lighting systems provide visual aids for pilot's orientation on final and are particularly useful when cloud base is low and visibility is poor.

- The pilot must also be always prepared to find several white lights, in addition to the red lights, marking the obstacles during night approach to the runway.

7. NIGHT TWO-SHIP FORMATION FLYING

a. Start Up

Engine start up is directed by the leader though the radio

b. Exterior Lighting

(1) After engine start-up.

- The leader selects the exterior lights to "STEADY" and "DIM", and switches on the anti-collision light.

- The wingman selects the exterior lights to "BRIGHT" and "FLASH" and switches on the anti-collision light.

(2) After taxi and once the aircraft are lined up, the leader switches off the anti-collison light and starts the flight operations.

(3) Past overhead, the leader selects the lights to "BRIGHT" and "FLASH" and switches on the anti-collision light.

c. Taxi

Both aircraft taxi on the taxiway centerline and maintain the same spacing as envisaged in daytime. It is recommended to refer to the taxiway side lights (two markers behind the leader) for spacing.

d. Flight Operation

For all flight operations, the same procedures as envisaged for daytime two-ship formation flying apply.
Leader directions are transmitted through the radio.

e. Night-Time Emergency Signals

All communications between the two aircraft are performed through the radio. In case of radio failure, communications are obtained by use of the exterior lights, the flashlight taken by the pilots before flight, or the spotlight.

- To draw attention, change light selection from "DIM/STEADY" to "FLASH/BRT" or vice versa.

- The signal made with the spotlight on steady red light at pilot's head level indicates an emergency. Press the red momentary illumination push-button one or more times (5 max), to define the type of emergency (conform to the already mentioned emergency code).

- Flashing the same light with red light indicates a radio failure (the aircraft with failed radio set changes to wingman position or maintains wingman position).

- Finally a series of white light flashes indicates the intention to land as soon as possible.

PART FOUR - CHAPTER XIV

FIRING TRAINING

TABLE OF CONTENTS

Title	Page
SECTION A - CHARACTERISTICS OF FIRING RANGES AND OPERATIONAL PROCEDURES	
Premise	14A-1
Air-to Air Ranges	14A-1
Air-to Ground Ranges	14A-3
SECTION B - AIR-TO-AIR RANGE FLIGHT PROCEDURES	
Premise	14B-1
Sight Check	14B-1
Rendez-Vous with the Tow Aircraft	14B-1
Entering the Air-to-Air Pattern	14B-2
Pull-Up from the Spacer Pass	14B-3
The Perch	14B-3
The Entry Turn	14B-3
The Reversal (Key Point)	14B-4
The Pursuit Curve	14B-4
Break-Off and Pull-Up	14B-6
Spacing in the Pattern	14B-7
Return from the Air-to-Air Range	14B-10
Target Scoring	14B-10
SECTION C - AIR-TO-GROUND RANGE FLIGHT PROCEDURE	
Premise	14C-1
Range Check in Procedure	14C-1
Entering Range Traffic	14C-1
Departing the Range	14C-2
Computing Pattern Conditions	14C-2
Skip and High Drag Bombing	14C-3
Low and Very Low Angle Strafing	14C-7
Rocketry	14C-11
High Angle Strafing	14C-14
High Angle Dive Bombing	14C-18
SECTION D - FILM ASSESSING	
Film Assessing	14D-1
Assessing Aerial Attack Film	14D-1
Other Uses of Assessing Charts	14D-4
Assessing Room Equipment	14D-6
Assessing Chart Construction	14D-6
Practice Firing	14D-10
Requirements Applicable to Qualification Missions	14D-11

PART FOUR - CHAPTER XIV

SECTION A - CHARACTERISTICS OF FIRING RANGERS AND OPERATIONAL PROCEDURES

1. PREMISE

To acquire skill and demonstrate the skill level attained in air-to-air and air-to-ground firing with all types of weapons, the pilot should have the possibility of performing attacks against practice targets which allow a score to be assigned to the mission (by qualified judges).
This type of training must be performed as frequently as possible under strict and continuous surveillance of a qualified firing instructor who is also responsible for the discipline and the compliance with the applicable operationg procedures during flight.
Obviously this Chapter, rather than provide data and technical instructions, serves as a guide for the operational use of the aircraft in firing training missions.
This Chapter will therefore describe the targets and their location in the firing ranges, the procedures in force at the ranges, the safety precautions, and the method to evaluate the results of firing.
The instructions, the specific orders and the information concerning the firing ranges and procedures in force remain a to the responsibility of the concerned commands.
The evaluation method and the assignment of the score to the firing missions are reported herein for information only, as the directives and orders of the concerned Commands and Activities will apply.

2. AIR-TO-AIR RANGES

a. General

An air-to-air range is a designated airspace reservation above an uninhabited land or water area. This reservation must of necessity be rather large because of the range and striking power of the projectiles fired by fighter aircraft. For example, if a target is towed at an indicated airspeed of 165 to 180 KIAS, the average range should be a minimum of 23 NM long and 6 NM wide. A tipical air-to-air range is shown in the figure 14-1.
The range may be identified either by prominent landmarks or by range markers easily wisible form the air.

b. Safety Precautions

Safety measures will be obeyed in accordance with the provisions of local Air Force Regulations.
Air-to-air passes on a towed target will terminate at a minimum of 600 ft range, or 15° angle-off whichever occurs first.
Firing will not be conducted when weather conditons are such that the pilot of the two aircraft cannot determine the range boundaries, unless adequate means, such as radar coverage, have been established and approved at major command level to insure that the range is clear and participating aircraft are within the boundaries of the range.
The commander should issue timely warning through local press and radio

to prevent uniformed persons from trespassing on the range during periods that training is in progress. When the range is not in continuous use throughout the year, the commander should notify the Air Force responsible agencies, and commanders of nearby military and naval installations, Civil Aviation Agencies and corresponding maritime organizations, to preclude aircraft, or shipping as in the case of overwater target areas, from trespassing during firing periods. The range will be declared a danger area during firing periods.
After completion of firing and prior to landing, pilots will turn off all armament switches, and comply with local safety regulations.
Under no circumstances will a pilot fire on a closed range, or when he has negative radio contact with all other members of the flight and the tow aircraft.

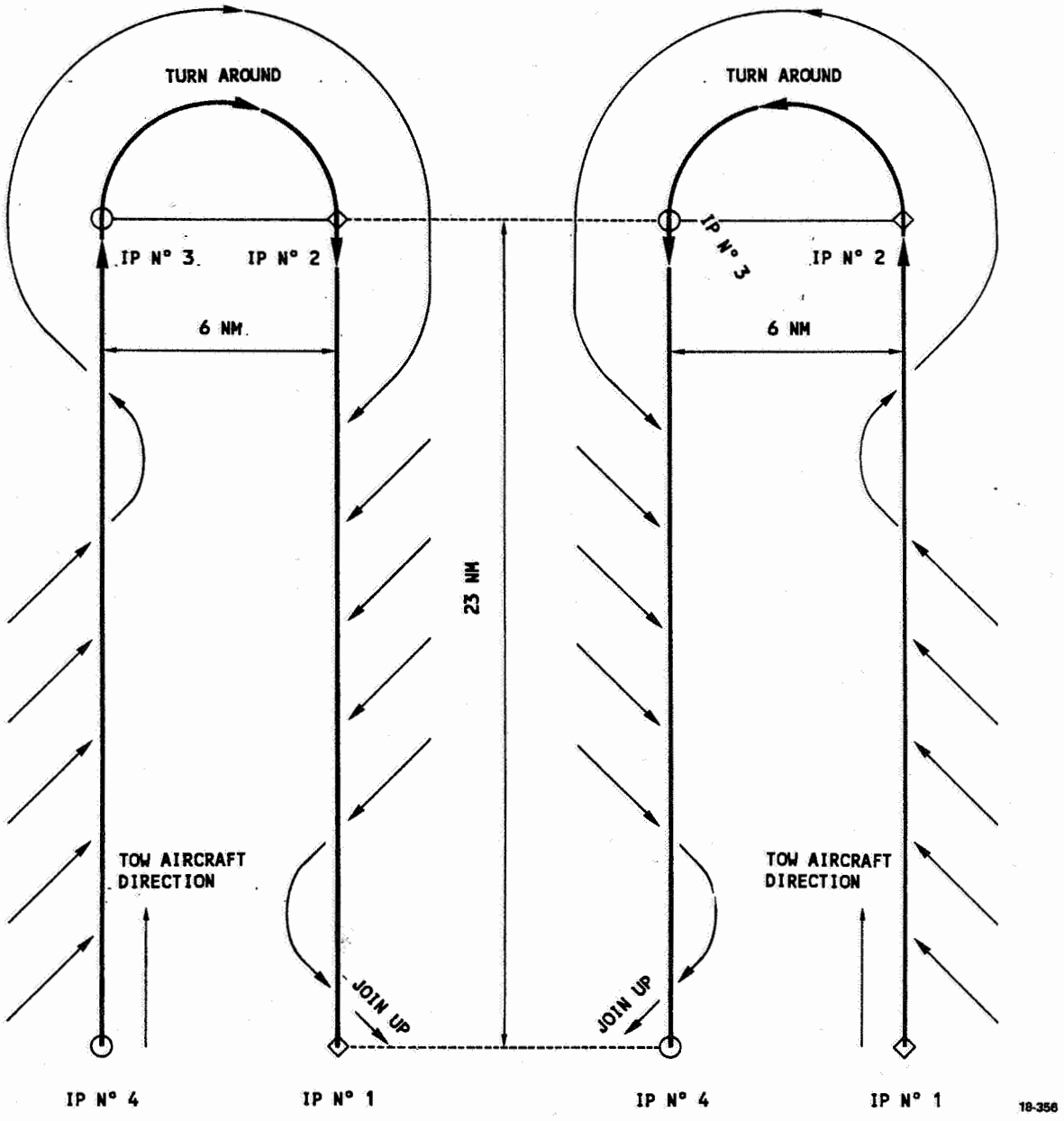


Figure 14-1. Typical Air-to-Air Range

Commanders will issue such local rules and regulations as are necessary to prohibit aircraft carrying live ammunition from flying over any area where accidental discharge or release of the ammunition might cause damage to government or private property, or endanger life.
Unit commanders must be sure that all personnel towing targets or firing on the range are thoroughly familiar with all range rules and procedures. It will be the responsibility of the unit commander to see that these rules and procedures are stricly enforced.

c. Flight Pattern

Aircraft equipped with aerial machine guns will utilize the standard 90° high-side type pass when firing at towed targets. This pass may be initiated from the right or left side of the target, depending upon the direction of the bullet travel. The air-to-air pattern on any target will contain a maximum of four aircraft at any time.

3. AIR-TO-GROUND RANGES

a. General

The selection of a site for a ground attack range requires that a maximum safety limit be maintained in order to protect personnel and equipment. It must be clear of obstructions and should be isolated by a minimum distance of 2 NM from all other installations. If other than practice ammunition, rockets, and bombs are to be used the commander must set up corresponding safety limits and range patterns.
The surface of a range should be level and if possible, soft enough to prevent or minimize ricocheting of the projectiles fired. The surface should be dug up either by plowing or harrowing for a distance of 50 ft in front of and behind all low angle strafe targets to insure maximum bullet absorption. This should be done at frequent intervals to insure that the surface does not harden.

b. Control Tower

The range control tower should be at least 9 meters high and located for ease of observation of targets and pattern. The distance from the targets will vary with the terrain.
A control panel should be at the base of the control tower, in such a position as to be easily visible to the pilot turning in on his firing pass. This panel should be at least 3 x 3 meters and constructed so as to be easily changed from red to white. The position of this panel opens and closes the range. A red panel indicates a closed range, a white panel, an open range. This panel, in addition to radio and flare gun, will prevent pilots from firing on a closed range. Items of equipment necessary to conduct operations are located in the control tower.

The minimum of equipment is as follows:

- Two-way radio equipment.
- Wide vision binoculars.
- Flare gun.

c. Spotting Tower

The construction of the spotting tower can be similar to that of the control tower. There should be a telephone system between the control and spotting tower and a duplicate plotting method in the spotting tower.

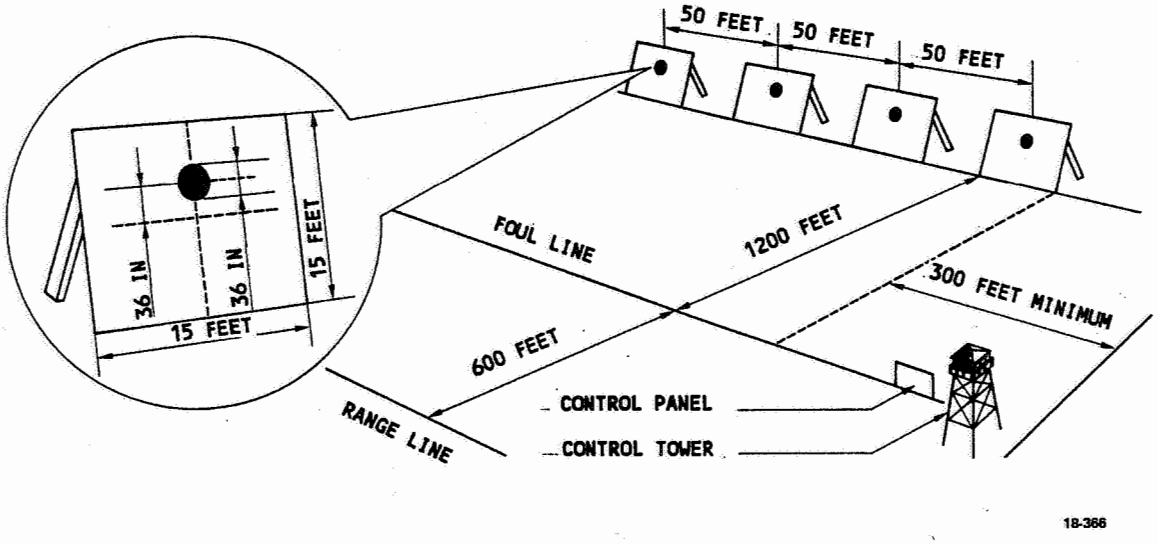


Figure 14-2. Low Angle Strafing Range

d. Low Angle Strafing Range

A low angle strafing range has normally 6 to 8 targets placed as shown on figure 14-2.
Each target is 15 ft square (4,50 x 4,50 m). The 3 ft (90 cm) bull's-eye is placed 3 ft above the center of the target to take care of gravity drop if the aircraft is harmonized for shorter ranges. (The 2-mil pipper coincides with the 36-inch bull at 1500 ft range). The targets are mounted about 80° from the horizontal, and are located 1200 ft from and parallel to the foul line. The target structure should permit easy removal of the panels for scoring. After each sortie a new target should be used, or the old ones carefully patched. Merely marking the previous bullet holes is not sufficient to insure correct scoring.
Colored ammunition will aid in scoring, as some ricochet holes are very similar to actual bullet holes. Due to the angle of penetration, a highly visible color such as red or green will stand out the best.

e. Skip Bombing Range

The skip bombing range is very similar in layout to the low angle strafing range. There are two main differences. Each target is 10 x 20 ft (3 x 6 m), and the foul line is located 750 ft (225 m) from the targets. The layout is shown in figure 14-3.
The terrain within a radius of 2 NM must be cleared of any obstructions that might interfere with the lengthly low level approaches.
The targets may be constructed from used aerial targets sewed together. For visibility the targets should be painted a color in sharp contrast to the background.

f. Dive Bombing, High Angle Strafing and Rocketry Range

The dive bombing, high angle strafing, and rocketry range consists of a pyramidal target or other suitable aiming point, control tower, spotting tower, and scoring system. The pyramidal target is 8 x 8 x 8 ft (2,40 x 2,40 x 2,40 m) and is placed at the center of 150 ft (45 m) circle. The layout is shown in figure 14-4. The circle may be constructed of any material cheaply procured such as used automobile tires. The color of the circle outline and the pyramid should contrast with that of the surround-

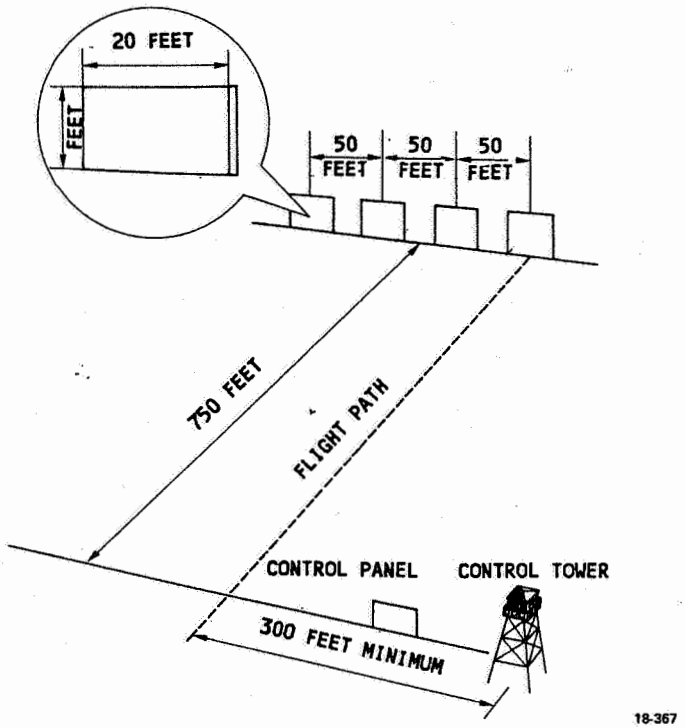


Figure 14-3. Skip Bombing Range

ing terrain. The spotting stakes are placed at 15 ft intervals, with one line perpendicular to the control tower, and the other perpendicular to the spotting tower. An alidade can be used as an alternate method of plotting impact points.

One method for spotting is to place two lines of numbered stakes in front of the target as shown in the drawing of the range layout. One line of stakes is perpendicular to the line from the spotting tower to the center of the target. The other line of stakes is perpendicular to the line from

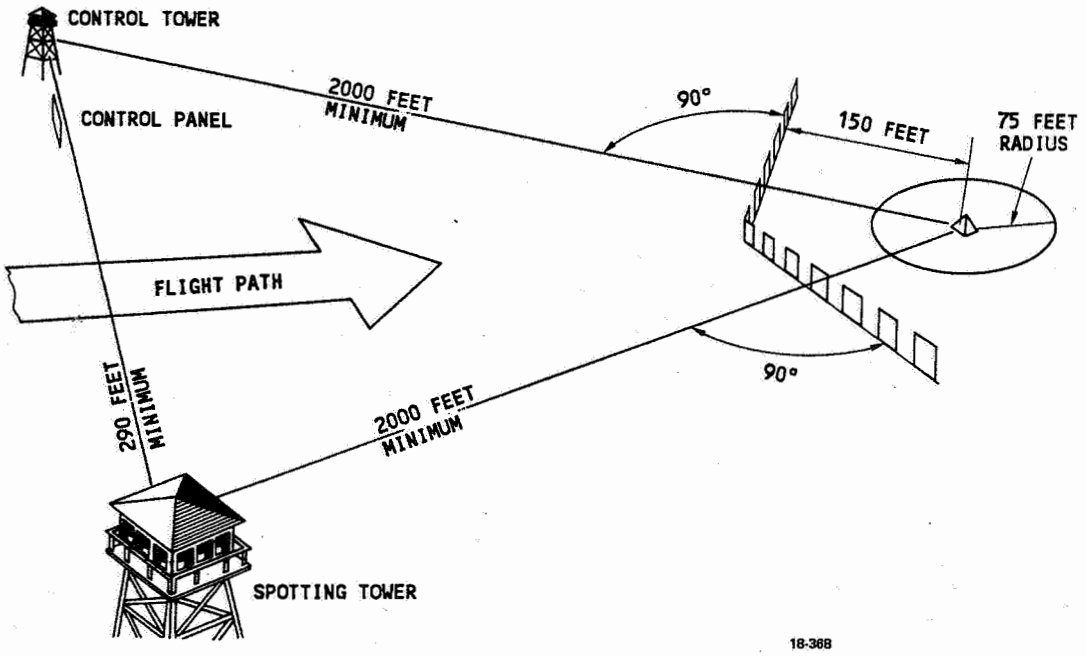


Figure 14-4. Range Layout for Dive Bombing

the control tower to the target. Each line of numbered stakes is 150 ft from the target at the nearest point. Each stake should have a number in black 30-inch hight on a board 3 ft square. Distance between stake centers is 15 feet. The number of stakes is governed by local policy, but the minimum scoring circle should be 600 ft in diameter. In other words the "line" of numbered stakes should be of sufficient length to enable the plotters in the two towers to plot impact points for a radius of 300 ft around the bull's-eye. The arrangement of the stakes is shown in figure 14-5. With the above arrangement, scoring can be done by observing the impact in relation to the nearest numbered stake. The stake numbers and approximate location of impacts are noted and sketched on a card and later plotted on a plotting sheet.
Another method for spotting is by use of the simple alidade of the type shown in figure 14-6.

g. Consolidated Air-to-Ground Range

The three types of ground ranges may be easily consolidated. With the addition of another spotting tower and duplicate targets a dual range can be laid out as shown in figure 14-7.
The dual range is desirable, because it offers the possibility of right hand and left hand patterns, preventing a pilot from becoming a "left" or "right" pilot. Furthermore, one low angle strafing range may be scored while firing is being conducted on the other.
The recommended range line is 600 ft from and parallel to the foul line. The range line is the maximum distance from the targets where ordnances is discharged. This is to confine the skip bombing and low angle strafing ranges. However in some instances, at the discretion of the unit commander, the range line may be moved nearer to or farther from the foul line.

h. Range Procedures

All pilots will be thoroughly briefed on safety precautions and range procedures. Each flight will proceed to the range in accordance with local directives and establish radio contact with the ground range. Each pilot will then check in with the range officer giving his position in the flight, aircraft number, and name (or squadron number).

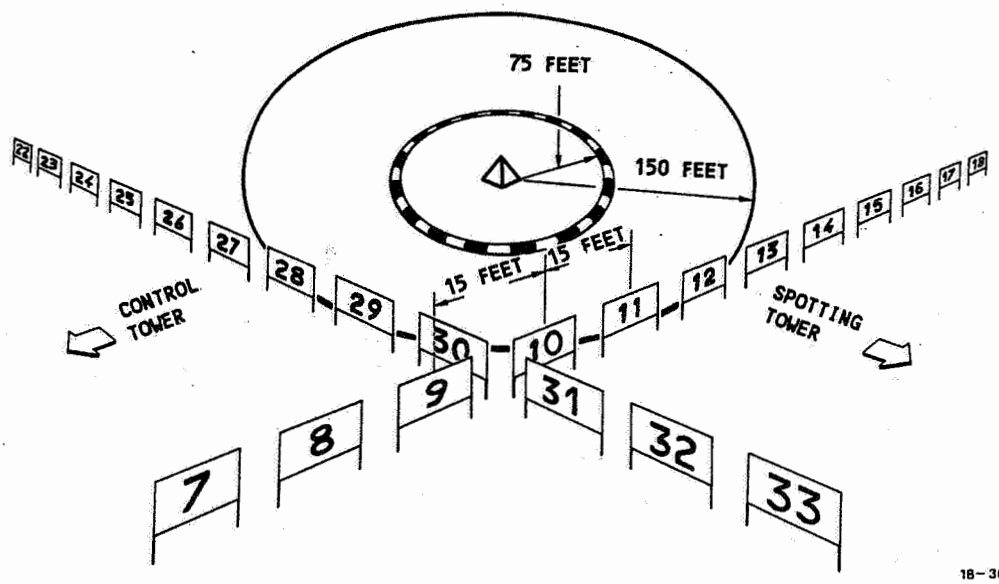


Figure 14-5. Arrangement for Scoring Stakes

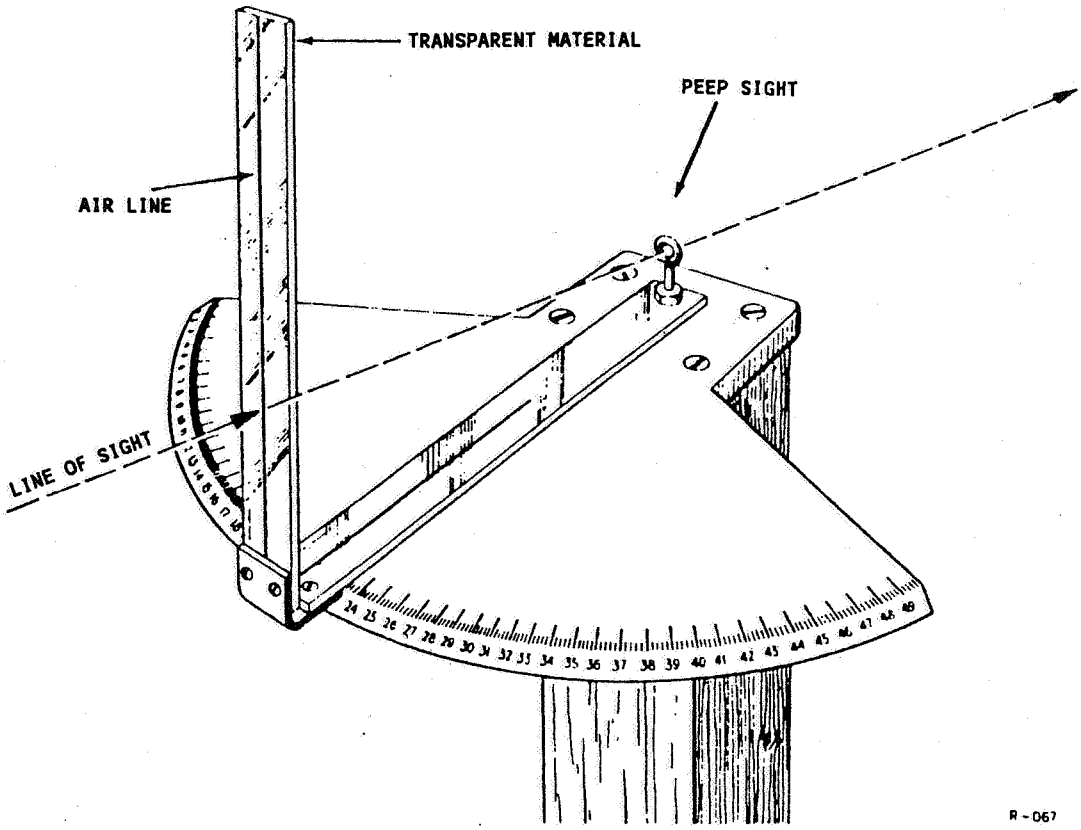


Figure 14-6. Simple Alidade

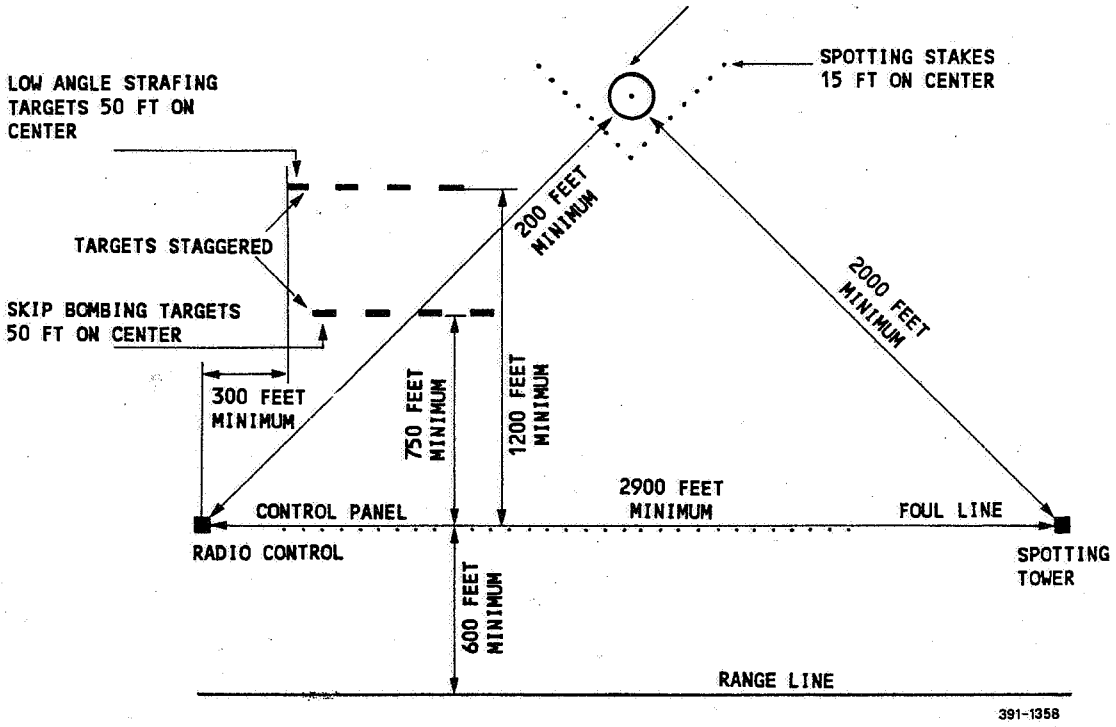


Figure 14-7. Consolidated Air-to-Ground Range

Upon reaching the range, each pilot will make a spacer pass at a minimum of 2000 ft above ground, to doublecheck the control panel, establish flight spacing, and enter the standard rectangular pattern. The pattern is shown in figure 14-8.
Each pilot will call his number and control panel color each time he commences the final turn on to his assigned target.
If a dual range is being used, the pilot will at this time also state the range. All patterns will be flown in such a manner to insure that the nose of the aircraft is never pointed at the control tower.
Dive bombing and rocketry patterns must be flown so that the flight path while firing is from the towers toward the target and perpendicular to a line between the control and spotting towers. Dive angles, slant ranges, and minimum altitudes will depend upon the type of missions flown. The figure 14-9 shows a method for determining the aircraft's altitude above ground level during skip bombing.

i. Safety Precautions

Safety measures will be observed in accordance with Local Air Force Regulations. The commander should issue timely warning through the local press and radio to prevent uninformed persons from trespessing on the range during periods that training is in progress.
After completion of firing, and prior to landing, pilots will turn off all armament switches, and comply with local safety regulations.
Under no circumstances will a pilot fire on a closed range or when he has negative radio contanct with all other members of his flight and the range.

Commanders will issue such local rules and regulations as are necessary to prohibit aircraft carrying live ammunition, practice or live bombs and rockets, from flying over cities, towns, or any areas where accidental firing or dropping might cause damage to government or private property or endanger life.

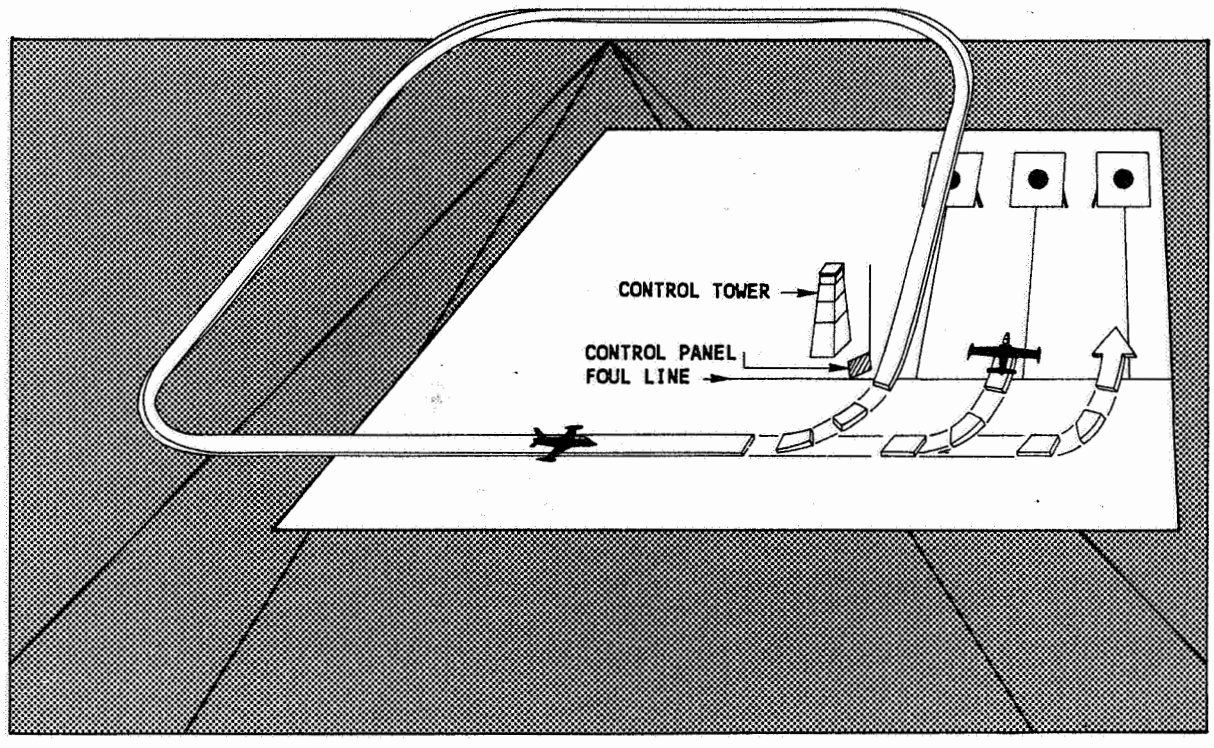


Figure 14-8. Flight Pattern from Low Angle Strafing and Skip Bombing

NOTE

Bombing and rocketry range procedures and specification in this manual are designed for the use of practice bombs and rockets. In the event other than practice bombs or rockets are used, appropriate range procedures and specifications will be adopted to maintain safety.

Unit commanders must be sure that all personnel operating the ranges or firing on them are thoroughly familiar will all range rules and procedures. It will be the responsability of the unit commander, usually through the range control officer, to see that all procedures and safety precautions are strictly enforced. The range officer should inspect the conditions of the range, especially the area around the low angle strafing and skip bombing targets, and insure that crash and fire equipment is standing by before opening the range for firing.
There will be a maximum of four aircraft in the air-to-ground pattern at any one time. The range officers will close the range if he is unable to establish radio contact with the flight. He will signify this by changing the control panel to red and/or firing red flares.

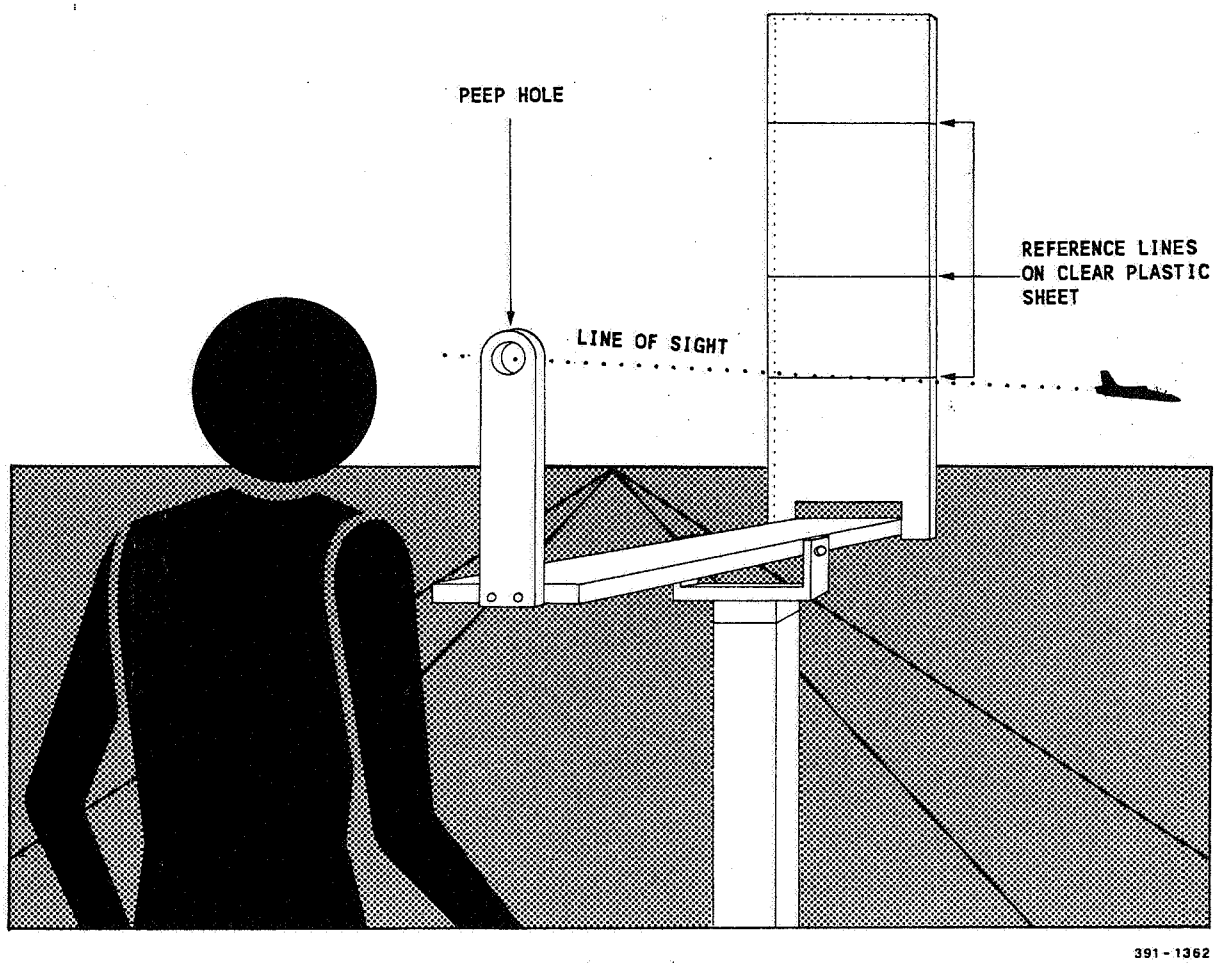
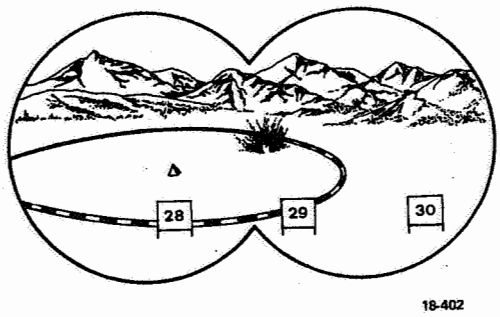


Figure 14-9. Method of Determining Altitude AGL Skip Bombing



IMPACT POINT = 28 3/4

Figure 14-10. Bomb Plot Example

j. Scoring Methods

Low angle strafing and skip bombing scores are usually obtained as a percentage by dividing the number of hits by the total rounds fired or bombs dropped. Local policy determines reduction in score due to fouls or other violations during practice firing.

Dive bombing, rocketry, and high angle strafing plots are scored as footage error from the bull's-eye. The number of the stake nearest the center of the impact is phoned to the control tower from the spotting tower. (The plots may be spotted to the nearest 1/4. In the situation illustrated in figure 14-10, for example, where the impact points in three-fourths of the distance between stakes 28 and 29, the plot is 28 3/4).
The impact point of the projectile is at the intersection of the line from the spotting tower to the stake and the similar line from the control tower. The footage error and cock position is determined from the score card and is called to the pilot to enable him to correct his next attack. The slant range and dive angle must be entered on the score sheet. The range and angle may be determined with a "harp" like the one shown on the figure 14-11.
Gun camera film should be utilized in conjunction with the above instrument. The film can be assessed to determine the slant range and dive angle.

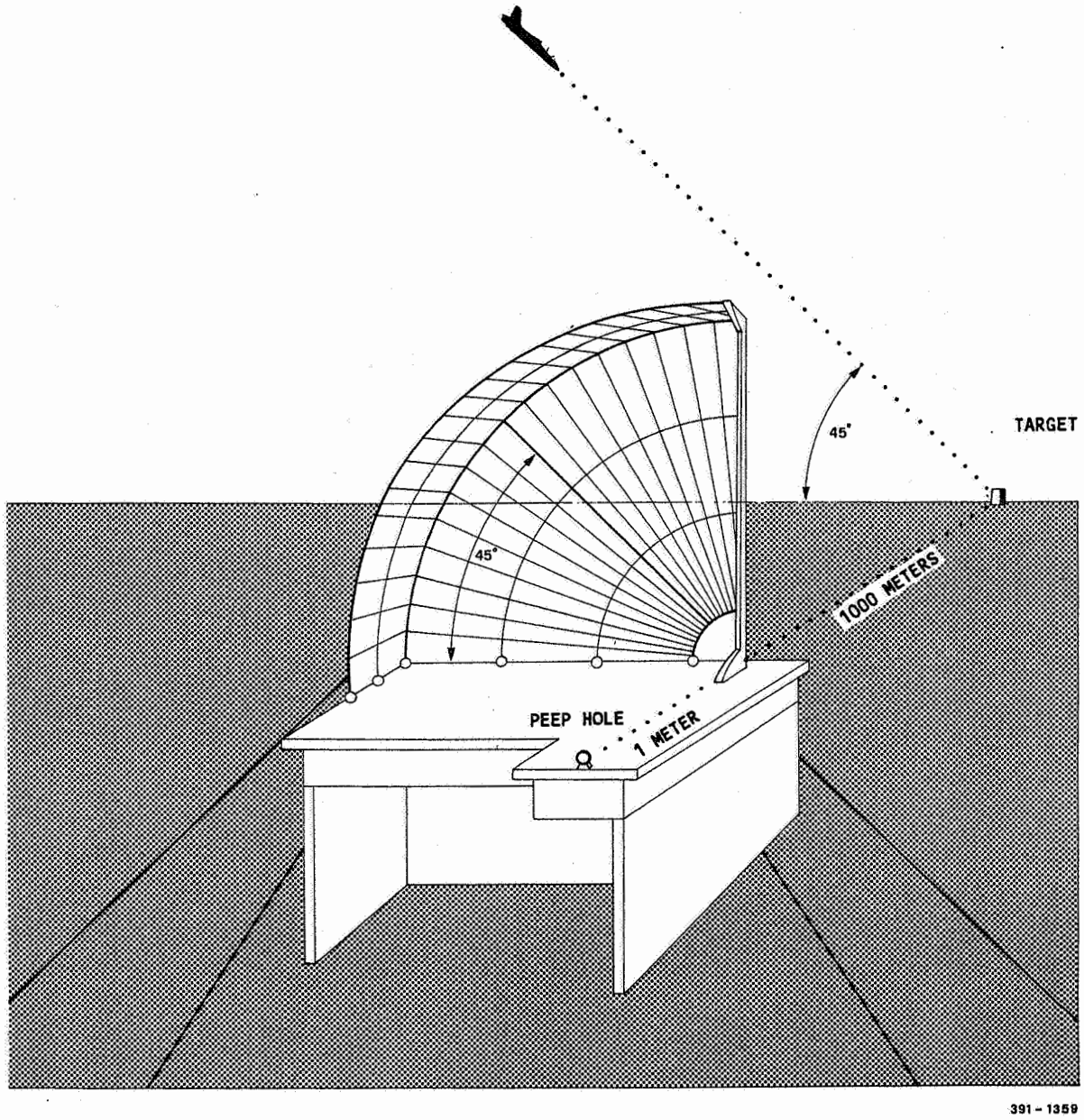


Figure 14-11. "HARP" for Estimated Slant Range and Dive Angle

PART FOUR - CHAPTER XIV

SECTION B - AIR-TO-AIR RANGE FLIGHT PROCEDURES

1. PREMISE

The standard air-to-air pattern should be performed with a flight of four aircraft, each aircraft armed with two gun pods caliber 0,50 (or caliber 7,62 mm) installed on underwing station No. 3 and No. 4. If required, only one of the pods may be loaded.
Also when flying dry runs using the gun camera only, it is suggested to configurate the aircraft with two gun pods to accustom the pilot to maneuver in the same aircraft load and configuration as in a combat mission.
It is not advisable to perform air-to-air practice gunnery with the underwing tanks installed, though empty, or with any other pylon-suspended store. This is not determined by structural or controllability factors but only because the speed, maneuvrability and acceleration parameters will be altered with respect to the aircraft operational characteristic of the standard gunnery mission.
The power settings, airspeed and attitudes suggested for a standard air--to-air gunnery pattern and the procedure to perform coordinated attack against banner target A6B towed at 165 KIAS at 12 000 ft altitude are shown in figures 14-16, 14-17 and 14-18.

2. SIGHT CHECK

The fight leader will move the flight to an IN TRAIL formation as the flight is proceeding to the range area.

NOTE

It is suggested to change the personal, or aircraft, radio call sign to an "operational" radio call sign as follows:

- All the formation: a short nick name, as "LION FORMATION".
- The leader is therefore: "LION ONE" or "LION LEADER".
- The wingmen will be: "LION TWO", "LION THREE", "LION FOUR".

If the towing aircraft is committed to a specific formation, the call sign will be, i.e. "LION TARGET".
(brief and easy names like lion, tiger, puma, fox, should be assigned to the various formations).

Assume positions 500 to 600 m in trail of the plane in front of you.
Figure 14-12 shows the trail configuration at 500 meters.
Figure 14-13 shows the A/A reticle at 300 meters.

3. RENDEZ-VOUS WITH THE TOW AIRCRAFT

The flight will proceed to the range in the in-trail formation, climbing to an altitude of at least 1000 ft and not more than 4000 ft above the proposed tow altitude. The flight leader will contact the tow aircraft approximately one minute from the range so that a proper rendez-vous may

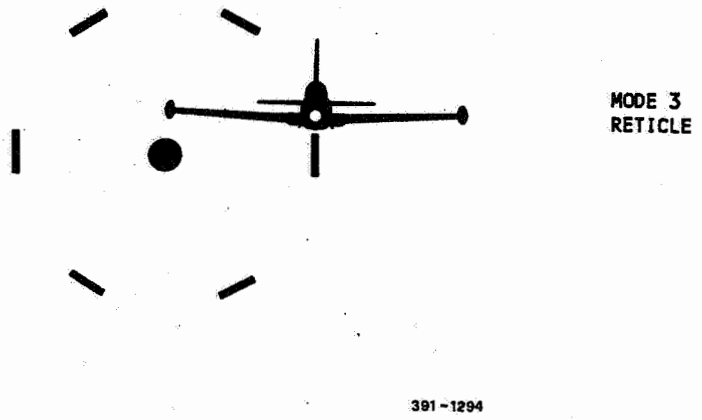


Figure 14-12. Trail at 500 Meters

be accomplished. After sighting the tow ship, and the time the tow ship is cleared to set course, the flight leader will position the flight for the spacing pass. As soon as the flight leader ascertains that the tow aircraft is setting course on the range, he will call for a radio channel change to the squadron frequency and ask for a radio check-in. The entire flight and the tow ship will check in.

4. ENTERING THE AIR-TO-AIR PATTERN

The flight leader will position the flight so that a spacing pass may be made past the tow ship. This pass will be started from a position approximately 1000 to 4000 ft above the tow altitude and 3 to 5 NM to the rear. The primary purpose of this pass is to set up the pattern spacing, and the aircraft in the flight should be spaced at least 500 to 600 meters in-trail. The flight leader will begin a shallow dive so that he will pass the tow ship on the proper side, at the tow ship's altitude.

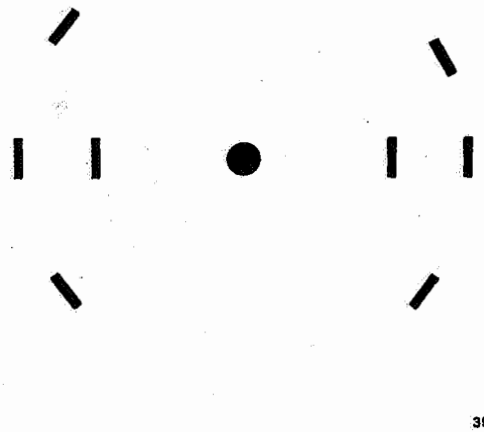


Figure 14-13. Mode 4 - A-A Reticle at 300 Meters

5. PULL-UP FROM THE SPACER PASS

As you pass 30 to 60 meters to the side of the tow aircraft, and 1500 to 2000 ft behind the preceding aircraft, initiate your pull-up and make your call, i.e. "lion two off". The pull-up off the target to the perch position is accomplished by smooth coordinated flying of your aircraft, enabling you to gain your attack position by turning your airspeed advantage into altitude and position advantage.
To do this, establish a climb from 20° to 30° before you roll into the turn toward the perch. Accomplish this initial part of the pull-up with your wings level as you pass the tow. The time involved should be used in orientating the position of other members of the flight. Now roll towards the direction of the perch, and having the position of the other flight members in mind, simultaneously look over your shoulder to regulate the amount of turn by your relationship to the tow aircraft. This climbing turn should continue until you are around to a position 70° to 80° from the flight path of the tow aircraft. This initial turn is dependent upon the type of aircraft and the altitude at which you are firing. At this point start a turn reversal still climbing, which will allow you now to see the aircraft preceding you in the pattern.

6. THE PERCH

By this time the aircraft preceding you will be on the perch, and relay to start his pass. As he is adjusting his position on the perch, you will see the aircraft opposite you in the pattern as he passes below you approaching to pursuit curve. Assuming that the aircraft preceding is in the proper position, you will fly your aircraft in such a manner as to place your perch just in front of where he initiated his pass, assuring yourself that you have the proper altitude and airspeed (190 to 200 KIAS).
You may find it necessary at this point to climb above the perch altitude to insure proper clearance as the preceding aircraft flies under you on his turn in. As you roll out on the perch, adjust your position, altitude, and airspeed properly so that you are straight and level, and paralleling the two aircraft's flight path. As you are accomplishing this, you should have the position of all members of the flight orientated again, and at the proper time you may initiate your pass. There is always a possibility that the pilot preceding you in the pattern may be out of position on the perch. This is where it is doubly important that you fly the proper pattern yourself and not just follow the man in front of you. If he is too far ahead, your perch position will be behind where he started his pass. In the event that his position is behind where it should be, it may become necessary to lose sight of him while putting your perch in the proper relation-ship to the target. This will be done only when you have assured yourself of a safe clearance and have received a call from him to the effect that he has you in sight. The same porcedure will be followed in the event that the pilot in front of you gets the pattern too wide. In holding your position in where it should be, only lose sight of him. When rolling into the perch, you may roll your aircraft all the way into an inverted attitude enabling you to keep sight of him as he turns in under you on his pass. As you approach the perch position always remember you are flying over or above the pilot turning off the perch into his pass.

7. THE ENTRY TURN

The optimum conditions would be to have every phase of each air-to-air gunnery pass identical; however, until you have fired a considerable

amount of gunnery, this is almost impossible to be achieved; this fact makes it important that you know the procedures to follow when you find yourself on the perch, and not in the proper position for the pass. This does not mean that you cannot make a pass from this position, as it is possible to salvage the pass by varying your entry turn to allow you to reach the turn reversal (key point) at the same relative position each time. Assuming that you are in the proper perch position you will initiate the turn in by starting a diving turn (approx. 20°) towards the target. This diving turn (approx 80°) should be completed with the target still just below the horizon (approx. 1500 ft), and in the center of the windscreen of your aircraft. At this time you will begin adjusting the piper to its proper position and begin tracking the target. This point in the pattern is referred to as the reversal or key point.
If your perch was out of position at the start of your turn in, it will be necessary to make adjustements in your rate of turn to allow you to arrive at the Reversal at the follow conditions:

- Distance = 3000 ft
- Altitude = 1500 ft
- Diving attitude = 20° to 30°
- Angle off = 90° to 75°

If you are ahead or close in, you must increase your rate of turn. If you are behind or wide, you must make a slower rate or turn.

8. THE REVERSAL (KEY POINT)

Regardless of the type aircraft or the altitude of the mission you are flying, the reversal is considered to be a key point, and unless it is set in the proper position your pass may become ineffective. At this point you should be 75° to 90° from the target's line of flight 3000 to 4000 ft away from the target, 190 to 200 KIAS below firing speed, and 1000 to 1500 ft above the target altitude. From this approximate position you can see that the greater the angle off, the further you should be from the target, and conversely the closer you are, the less the angle off should be.
The type aircraft, its turning radius, and the altitude at which you are firing are the prime factors in determining the conditions you will choose as optimum for the reversal point.

9. THE PURSUIT CURVE

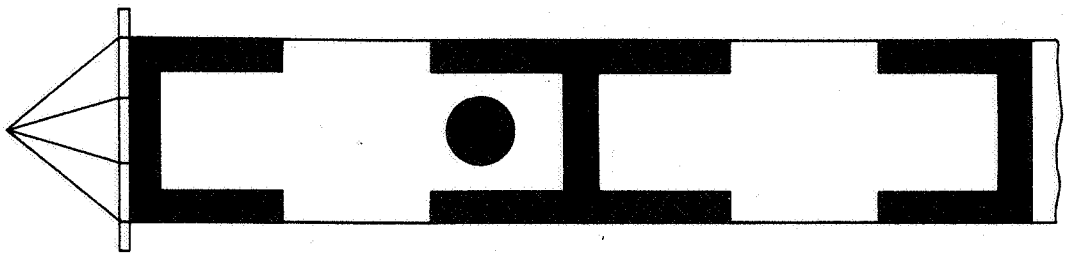
The goal you have been striving for thus far in the air-to-air pattern is to place your aircraft into a pursuit curve enabling you to bring your guns to bear on the target at a safe angle off, and in effective firing range. This pursuit curve will be a cone from 15° to 45° of angle off, 0° to 5° above the target's flight path, and from 1200 to 600 ft firing range.

NOTE

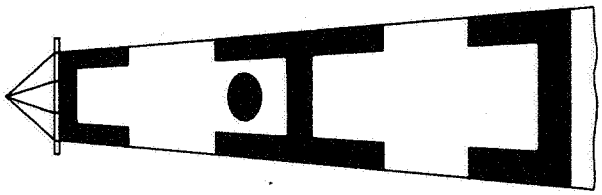
Do not fire up at a target.

The pursuit curve on your first pass should be used primarily to recheck and adjust the trim. Although you have trimmed the aircraft straight and level on the spacer pass, you may find that some aircraft will require just a little rudder trim to keep the ball in the center during this phase of the pass.

Smooth tracking in the pursuit curve, is generally considered to be the most important factor in effective air-to-air gunnery and rightfully so, however, to be 100 percent affective on every pass a combination of several techniques must be adhered to. You must know your sight, understand and be able to fly the air-to-air pattern, achieve the proper positions and airspeed, and most important, you must be coordinated.
One of the most common errors at this point is the inadvertent use of rudders. You will find that little or no rudder pressure is required if you have the aircraft properly trimmed.
The most effective means of acquaiting yourself with what the target looks like at different angles off is your film assessing. Know especially what it looks like at 15°: at this angle it will appear almost square. At lower angles, you will no longer be able to distinguish the bull's-eye, and the target will appear higher than it is long. See Figure 14-14. You will see this when you have allowed yourself to fall into what is called a "Tail



90 DEGREES



45 DEGREES

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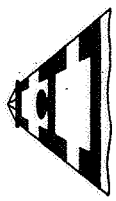


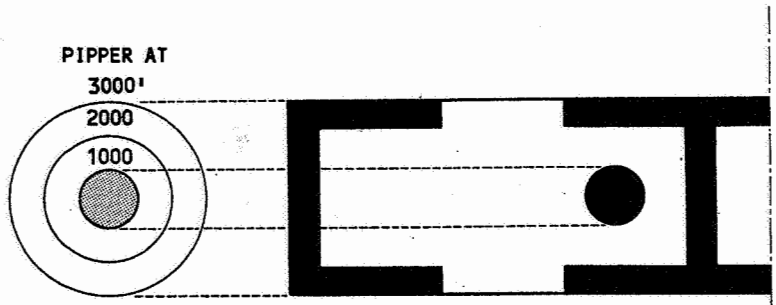
15 DEGREES

Figure 14-14. A6B Target at Different Angles Off

Chase". DO NOT pursue the attack under these conditions; break it off and position yourself properly on the next pass. If you fire at a lower angle than 15° you not only endanger yourself, but he tow aircraft as well. In assessing your target you can judge the angle at which you fired by the length of the holes. If more than five sets of three strands are cut in an A6B polythelene target, the projectile was fired from less than 15°. Range estimation is judged primarily by comparing the reticle of your sight to the six foot width of the target or the bull-eye on the target. You know that one mil subtends a width of one unit at 1000 units. This comparison is much more accurate than estimating range just by looking at the target without a means of cross checking your own judgement. Another cross check is by counting in your mind, the length of time it takes you to pass behind the target after you stop firing. This method is more valid for pegged range firing and does not tell you when to open fire, but merely gives you a rough idea, after the pass, as to whether you were out of range or not.
For example, let us assume that you are firing on a target 12 000 ft. Your firing speed is 320 KIAS, or 198 KTAS (334 ft/s), depending on your angle off, your closing speed is roughly 320 ft/s, therefore if, after you stop firing, it takes you two seconds to pass the target you can assume that your cease fire range was approx. = 640 ft. From this information you can see that it should take one to two seconds to pass the target after you cease fire, if you are coming into the proper range. See figure 14-15 for pipper/target relative size at different distances.

10. BREAK-OFF AND PULL-UP

The best means of picturing in your mind the break-off maneuver is to use your hands. Make one hand the target, and put the other hand in a simulated pursuit curve position. Now you can see that it would be possible to continue your pursuit curve and collide with the target; therefore, as you cease fire you must do a combination of two things simultaneously. Relax your back pressure, which if done alone, would allow you to miss the target by merely sliding behind it. This is not effective if you are at a low angle off. You must also bring your wings level at the same time. This maneuver is similar to what you would do in abruptly rolling out of a tight break in air-to-air tactics. This will prevent you from colliding with the target in the event you have fired in too close, or if the target has been shot off.
The break off will carry you to the opposite side of the target, and you should level your wings, fly up opposite the tow aircraft, and as you pull-up you will make the required call, i.e. "lion four, off".



- AT 1000 FT THE PIPPER APPEARS TO HAVE THE SAME DIMENSION OF THE BULLS-EYE
- AT 2000 FT THE PIPPER APPEARS TO HAVE A SIZE WHICH IS TWO TIMES THE BULLS-EYE
- AT 3000 FT THE PIPPER APPEARS TO BE EQUAL TO THE TARGET WIDTH

18-377

Figure 14-15. Pipper/Target Relative Size at Different Distances

11. SPACING IN THE PATTERN

Your first thought may be, since you probably have fired with only two or sometimes three aircraft in the air-to-air pattern, that four is too many. Notice in the figures 14-16, 14-17, 14-18 how simple, and more effective it is to fly with four aircraft. You can see that the numbers one and three are always opposite each other, and the same with two and four. You not only have ample separation for safety, but it will also aid you in good timing, and keeping track of the tow aircraft. If, as you are ready to turn in off the perch, you find that you have momentarily lost sight of the target, you can easily pick him up by looking ahead of the aircraft preceding you in the pattern.

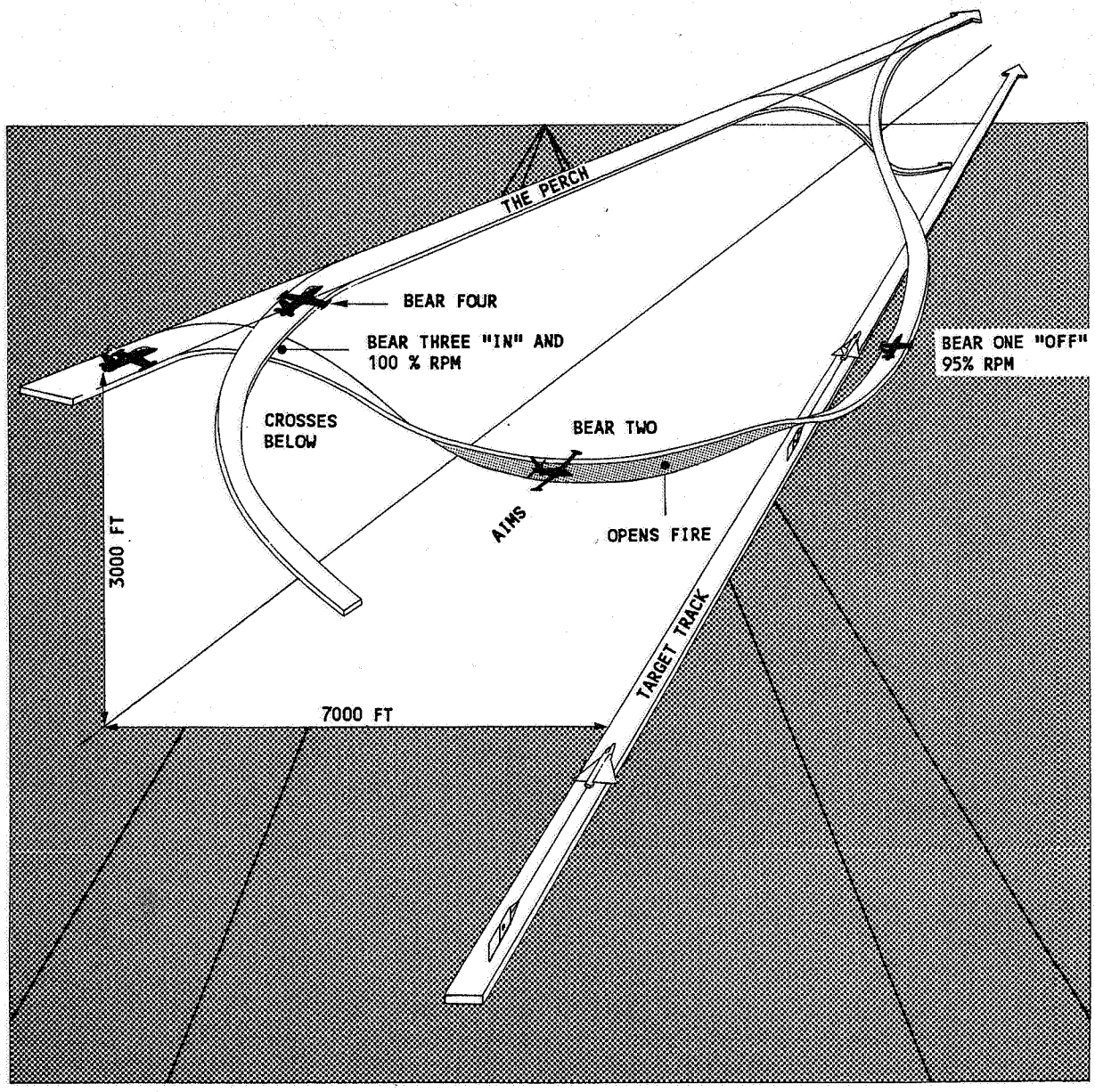


Figure 14-16. Relative Position of Fighters in Air-to-Air Range

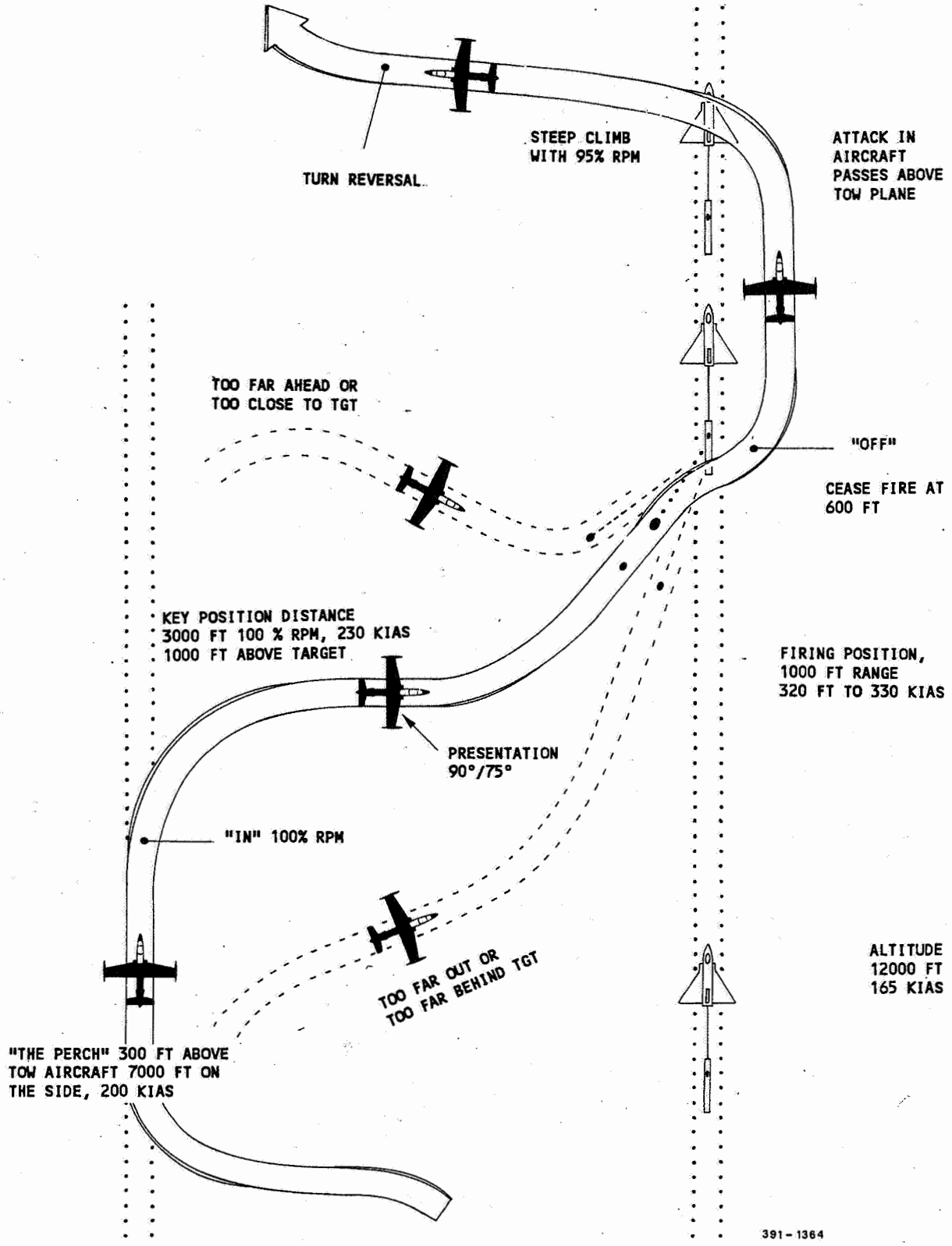
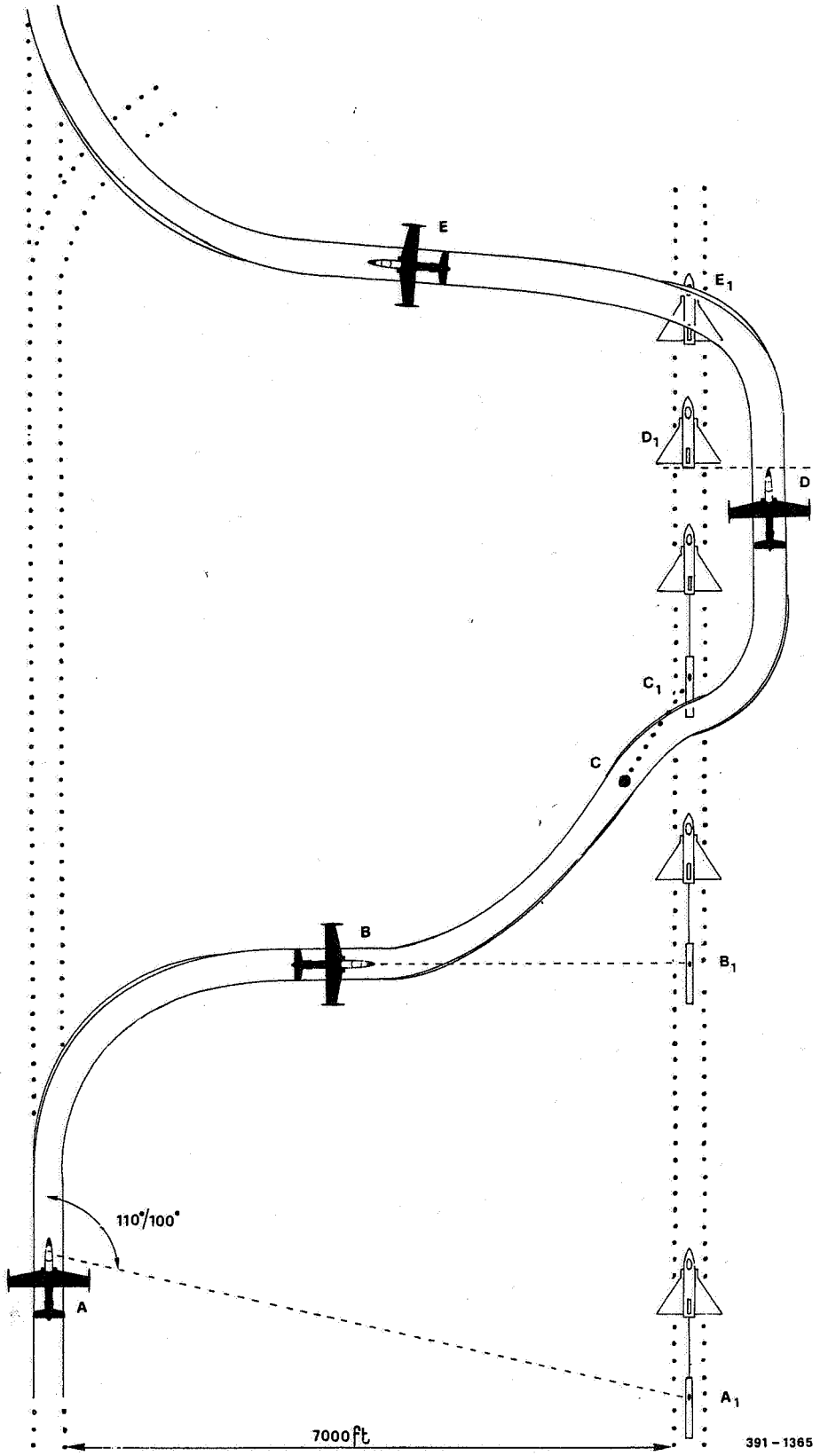


Figure 14-17. Air-to-Air Gunnery Pattern



A. FIGHTER 3000 FT ABOVE TARGET - 7000 FT APART - ANGLE OFF 100/110 DEG
B. FIGHTER 1500 FT ABOVE TARGET - 3000 FT APART - ANGLE OFF 90/75 DEG
C. FIGHTER 300 FT ABOVE TARGET - 1200/1000 FT RANGE - ANGLE OFF 30/15 DEG
D. FIGHTER SAME LEVEL OF TARGET - 100 FT LATERALY
E. FIGHTER 2000 FT ABOVE TARGET - 3000 FT APART - ANGLE OFF 80 DEG

Figure 14-18. Fighter to Target Relative Position

WARNING

- To avoid the danger of a mid-air collision, to keep out of the firing range of the following in formation aircraft when it is shooting to the target as well as to avoid the danger of hitting the towing aircraft it is necessary to follow scrupolously the undercited precautions:
- The "number three" aircraft will not start the "in" manoeuver till the "number one" declares the "off" (The same procedure will be followed by the "number two" with respect to the "number four").
- The aircraft which opens fire must be slightly higher than the banner (approximately 300 ft) NEVER BE LOWER.
- The pull-up toward the perch must be started with e steep climb, then the attitude will be eased in the final approach to the "perch".
- Along all the pattern each aircraft must keep well in sight the other three aircraft of the formation as well as the target.

12. RETURN FROM THE AIR-TO-AIR RANGE

After the flight leader completes his last pass on the target, he will call, "Lion leader off", and climb to the "two o'clock" (or "ten o'clock") position for join up.
The flight leader will also make a call that the armament switches are off.
As each member of the flight completes his last pass on the target, he will call "off". Prior to joining up with the flight, he will check his sight and gun switches "off", as indicated above, and he will make the mandatory call; i.e. "Lion two switches off".
The flight will join up in close formation.

13. TARGET SCORING

The score is computed on holes in the target against rounds fired.
Film assessing is by no means the only accurate method of assessing your mission. You should assess every target for the grouping and length of holes. The grouping of holes will tell you whether you are overleading or underleading. This could be caused by incorrect tracing, too high or too low an airspeed, or possible sight trouble. The groupings will also show if you are shooting high or low. This may be caused by incorrect tracing, inadvertent use of rudder, or possible sight trouble. The length or holes indicates the angle off at which you are firing. In pegged range i your passses are constantly the same, a cross check of the groupings and length of holes will tell you range and angle off.
Now compare your target assessing with your film, and you will have the information necessary to continually improve your proficiency.

PART FOUR - CHAPTER XIV

SECTION C - AIR-TO-GROUND RANGE FLIGHT PROCEDURE

1. PREMISE

All air-to-ground attacks should be effectuated by a four aircraft flight.

NOTE

It is suggested to change the personal, or the aircraft, radio call sign to an "operational" radio call sign as follows:

- All the formation: a definite short nick-name; as i.e. "LION FORMATION".
- The leader is therefore: "LION ONE" or "LION LEADER".
- The wingmen will be "LION TWO, LION THREE, LION FOUR".

(brief and easy names like: lion, tiger, bear, fox, puma should be assigned to the formations).

No aircraft can enter the range area if it is not able to get in touch in a two way transmission with the range control tower, and must immediately leave the range if the radio transmission cannot be maintained.

2. RANGE CHECK IN PROCEDURE

Prior to arriving at the range, the flight leader will give the proper signal for the flight to assume an in-trail formation. This formation should be reasonably close so that the flight leader will have complete control of the flight, approx. 30 to 40 meters between aircraft. The flight leader will advise the Range Control Officer of the flight call sign, the number and type or aircraft in the flight, and the type for mission to be flown i.e. "LION" leader with three wingmen for skip bomb and low angle strafe". The Range Control Officer will then request the flight line up.

3. ENTERING RANGE TRAFFIC

Approaching the range, the flight leader will turn the flight for the spacing pass over the proper side of the range. This turn will be entered with the flight in trail formation. As the turn is completed, the flight leader will signal for echelon on the proper side for the range traffic direction (left echelon for right traffic, right echelon for left traffic). This formation should not be a tight show echelon, but rather a slightly loose formation so that all members will have a chance to check the range and trim their aircraft without danger of collision. The spacing pass should be accomplished so that prior to breaking up, the flight will reach the desired firing speed for the mission being flown, and can trim their aircraft at that speed. It is the flight leader's responsibility to insure that the minimum altitude restrictions for spacing passes be complied with. Normally the spacing pass descends no lower than 2000 feet above the ground. As the flight leader passes over the target area, he will pitch up into a climbing turn to the proper pattern altitude on the downwind

leg. Each member of the flight will take a three second spacing interval and individually follow the leader. The Range Officer will notify the flight leader, prior to his spacing pass, as to whether the safety panel for the range is red or white. If a red panel is showing, the spacing pass is continued, and each aircraft enters the pattern normally. However, the entire flight will not descend below spacing pass altitude until the panel is changed to white and the flight is cleared to fire by the Range Officer. The flight leader will relay the "clear to fire" order to his flight.
At no time will a pass be made on a range, whether dry pass or firing, when a red panel is being shown.

4. DEPARTING THE RANGE

The flight will leave the range when all armament is expended, the range period is over, or a member of the flight has given the minimum fuel call sign.
The flight leader will advise the flight when he is making his last pass, and upon completing this pass will pull up to a normal downwind leg. At a point where the base leg is normally started, he will leave the traffic pattern with a turn towards the home base, using 84% power or an air-speed of 240 KIAS. He will turn off all armament switches.
As each member of the flight completes his last pass and climbs onto the downwind leg he will follow the same procedure. After each member of the flight has given this call the flight leader will call for a radio channel change to squadron frequency and the flight will check in.

5. COMPUTING PATTERN CONDITIONS

In the following chapters on the different phases of air-to-ground weapon training, the patterns are discussed thoroughly with regard to size, dive angles, etc.
In your particular unit you may, because of terrain, or type of aircraft, find it necessary to vary from those outlined. The following diagrams may be used as a guide in computing your pattern size.

Remembering the simple trigonometrical function (Co-tan $\alpha = \frac{\text{adjacent}}{\text{opposite}}$)

(fig. 14-19). All that is necessary is a set of natural trigonometric function tables. For example. We want to find how our base leg must be from the target if we are firing in a 20° dive and the base leg altitude is 3000 ft above the ground level at the target. Now by filling in the formula we know that the

(C) = Co-tan α x B

(C) = 2,747 x 3000

(C) = 8241 ft

Now we can fill in distance C and can also see that if you have the dive angle of 20° and you must set your base leg, because of some obstacle, at 7500 ft from the target that

$$(B) = C \times \tan \alpha \text{ or } \frac{C}{\text{Co-tan } \alpha} = \frac{7500}{2{,}747} = 2730 \text{ ft AGL}$$

- Pull-up 4 g attained in 2 s.
- Aircraft mass at moment of firing = 4135 kg
- Range elevation 0 ft - ground temp + 25 °C.

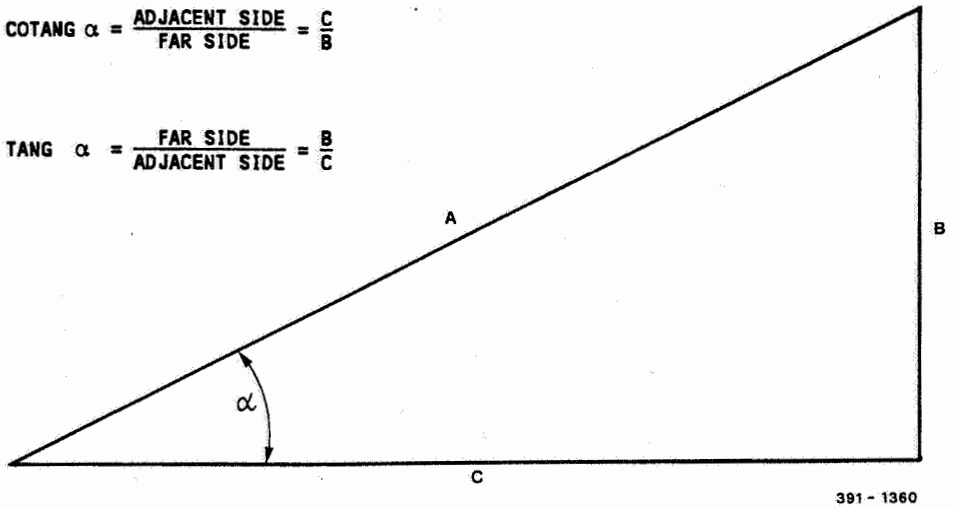


Figure 14-19. Calculation of Dive Parameters

WARNING

Release altitude AGL calculated for a pull-up of 4 g only for target at sea level.
For different target altitude recovery altitude may be below minimum safe altitude.

6. SKIP AND HIGH DRAG BOMBING

a. Introduction

Skip and high drag bombing will be normally conducted during the first part of air-to-ground gunnery training phase, in conjunction with low angle strafing missions. The armament for this type mission will be two machine gun pod, installed on the underwing stations 3 and 4 and two MK76 practice bombs with adapters installed on the underwing stations 2 and 5.
The bombs should be dropped during the first part of the mission. Since all phases of the mission up to the traffic pattern itself have been covered, they will not be repeated in this paragraph.

b. Skip Bombing Pattern

Rectangular traffic patterns are used. There will normally be four skip bombing targets on the range. The leader drops on the target the closest to the tower, number two drops on the next one out, etc. If less than four targets are available, the instructor will assign firing order for each target.
With four aircraft in the pattern, the spacing between aircraft should be sufficient to allow a pilot to enter the firing run and sight on the target area without bringing his armament to bear on the preceding aircraft. Normally, this will mean that the aircraft turning onto the final approach will arrive at the proper position for his turn just as the preceding aircraft is completing his firing pass. At this time, the third aircraft will be approaching his turn onto the base leg, and the fourth aircraft will be completing his recovery onto the downwind leg. In order

to maintain the proper spacing in the pattern, it may be necessary to vary the position of the downwind leg in relation to the range. If inadequate spacing exists, the downwind leg should be angled out, so that the following aircraft will cover more distance, thereby increasing the spacing. If excessive spacing exists, the following aircraft should attempt to "cut off" the preceding aircraft, so that the spacing will close up.
In either case, the base leg position should be sacrificed for spacing, nor should the following aircraft attempt to obtain proper position by changing airspeed, as this may result in a poor pass. If the following pilot is unable to gain proper position prior to entering the turn onto the base leg, he should complete the pass making a dry run if too close or a normal pass if too far back, and than correct the spacing for the next pass. At all times, all pilots will keep the aircraft ahead of them in positive sight.

c. Skip and High Drag Bombing Techniques (fig. 14-20)

(1) As the flight leader pulls up onto the downwind leg after the spacer pass, he will call the flight to set up sights and switches for skip bombing. As you reach the downwind leg, turn the sight and the armament control panel to the required settings.

(2) You should be at an attitude of 2500 ft AGL on the downwind and base legs and the power should be adjusted to approx. 87% to maintain 250 KIAS.

(3) The flight leader will establish the correct base leg position at a distance approximately 2 NM horizontally from the target.

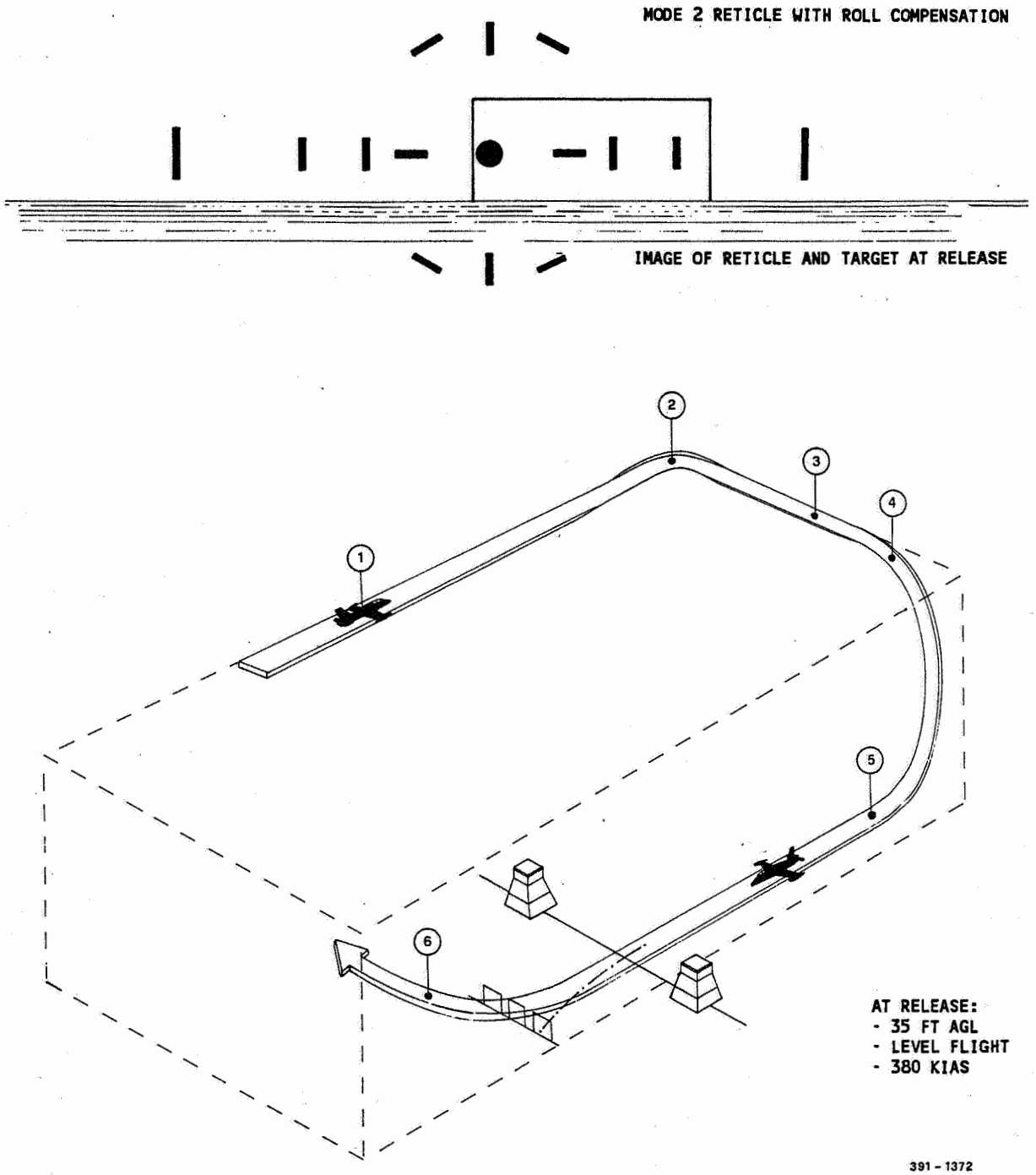
(4) Just before the turning final, a mandatory radio call will be made by each pilot, giving the panel color. After turning onto the base leg, begin a nose down turn onto the final. Continue this descending turn to be lined up with the range and target, at an altitude of 150 to 200 AGL as the turn onto final is completed, at least 5000 ft short of the drop point. This altitude and distance will allow for final maneuvering as you descend to the drop altitude.

(5) In lining up for the drop, you should line up the bomb to be dropped with the center of the target. The left bomb will drop on the first impulse from the bomb release button and you must allow for the fact that the bomb area is not directly under the sight line but 9 or 12 ft to the left and right of the sight line. A good reference for this linear difference is the post which holds the bomb target erect.

(6) When dropping the left bomb, align the sight pipper vertically just inside of the right post, and for the right bomb just inside the left post. This will allows maximum margin for error on both sides of the bomb. As you are aligning the pipper, you should be carefully adjusting your altitude to maintain the desired 35 ft above the ground.

(7) As you level off at 35 ft (300 ft for high drag bombing) and look through your sight, you will see that the pipper is on the ground well in front of the target, and as you hold your aircraft in level flight approaching the target, the reticle will seem to move forward along the ground.

(8) When the center of the reticle moves to a position just within the bottom edge of the target, you are at the proper release point. Depress the bomb release button to release the bomb at that instant.
Since a "hit" is scored at any time the bomb touches the target a certain degree of latitude exists in the release conditions. The bomb may hit the ground and skip through the target, or hit the target on the fly, and both will be scored as hits.



1. "BOMB" OR "DISP" PUSH-BUTTON DEPRESSED
   GUNSIGHT AT MODE 2
   DEPRESSION ANGLE AS REQUIRED
   ENGINE SETTING APPROX. 87% RPM
2. 250 FT AGL, 250 KIAS, APPROX. 87% RPM
3. TWO NM FROM TARGET, "MASTER ARMT" SWITCH UP
4. DECLARE "IN" AND ADVANCE THROTTLE TO APPROX. 95% RPM, 370 KIAS
5. 5000 FT FROM TARGET, 150 FT AGL, APPROX. 95% RPM, 370 KIAS
6. PITCH UP AND START TURN,; "MASTER ARMT" SWITCH DOWN, REDUCE RPM TO 87%

Figure 14-20. Skip Bombing Technique

(9) One of the greatest single error factors in the skip bombing phase is the inclination to release in a slight dive or climb. Since the sight is rigid, the sight picture will not be accurate in these conditions and the forces acting on the bomb will not satisfy the conditions established for solution of the skip bombing problem.
Great care should be taken to prevent violation of the 35 ft minimum altitude. The reason for this is obvious, for safety wise as well as for increased accuracy.

(10) The Range Officer informs each pilot as to where his bomb hits, and may give correction if necessary. Each pilot will acknowledge all calls form the Range Officer. If your first bomb missed the target, try to determine why, and correct the error on the next pass. Accurate error analysis is important in all gunnery training and particularly in this phase. In order to insure maximum accuracy in skip bombing, the exact dropping conditions outlined at the beginning of this chapter must be maintained. Variations of release conditions will alter the impact point of the bomb in the following manner:

- OVERSPEED AT RELEASE
  Overshoots the target
- UNDERSPEED AT RELEASE
  Undershoots the target
- HIGH RELEASE ALTITUDE
  Undershoots the target
- LOWER RELEASE
  Overshoots the target
- DIVING RELEASE
  Overshoots the target
- CLIMBING RELEASE
  Undershoots the target
- POSITIVE "g" AT RELEASE
  Undershoots the target
- NEGATIVE "g" AT RELEASE
  Overshoots the target
- SKID
  Line error in the direction of the ball.

Correcting for crosswind effect, in this problem, is relatively simple since the bomb will tend to follow the flight path of the aircraft even though the nose of the aircraft is crabbed into the wind. If the bomb is lined up with the target and the pipper is allowed to progress to the proper release point, all other conditions being normal, the bomb will hit the target. Head or tail wind will have little effect for this particular type of bombing pass. The rule of thumb for wind correction for low angle bombing is to apply two mils correction, into the wind, for every knot of crosswind.
The recovery from the low angle bomb pass is often the key to a well executed pattern. In recovering, the nose of the aircraft should be brought smoothly up to a climbing angle of approximately 40 degrees. After attaining this climb angle, the aircraft should be rolled into a turn in the direction of traffic and climb made to the downwind leg. After you have completed your bombing, place the master arm and the stores switches in the Off position.

8. LOW AND VERY LOW ANGLE STRAFING

a. Introduction

Low angle strafing will be conducted during the first part of your air-to--ground gunnery training phase, in conjunction with skip bombing. The armament load will be: two machine gun pods loaded with 90 rounds or two gun pods loaded with 60 rounds. Bombs and ammunition will be carried on each low angle mission and the strafing will be done after the bombs have been dropped.

b. Pattern Data

(1) Base leg altitude: 3500 ft AGL

(2) Base leg airspeed: 240 KIAS

(3) Power setting: 84%

(4) Dive angle: 20°

(5) Firing airspeed: 360 KIAS

(6) Slant Range: 2200

(7) Foul line: 1600 ft

(8) Minimum recovery altitude: 100 ft.

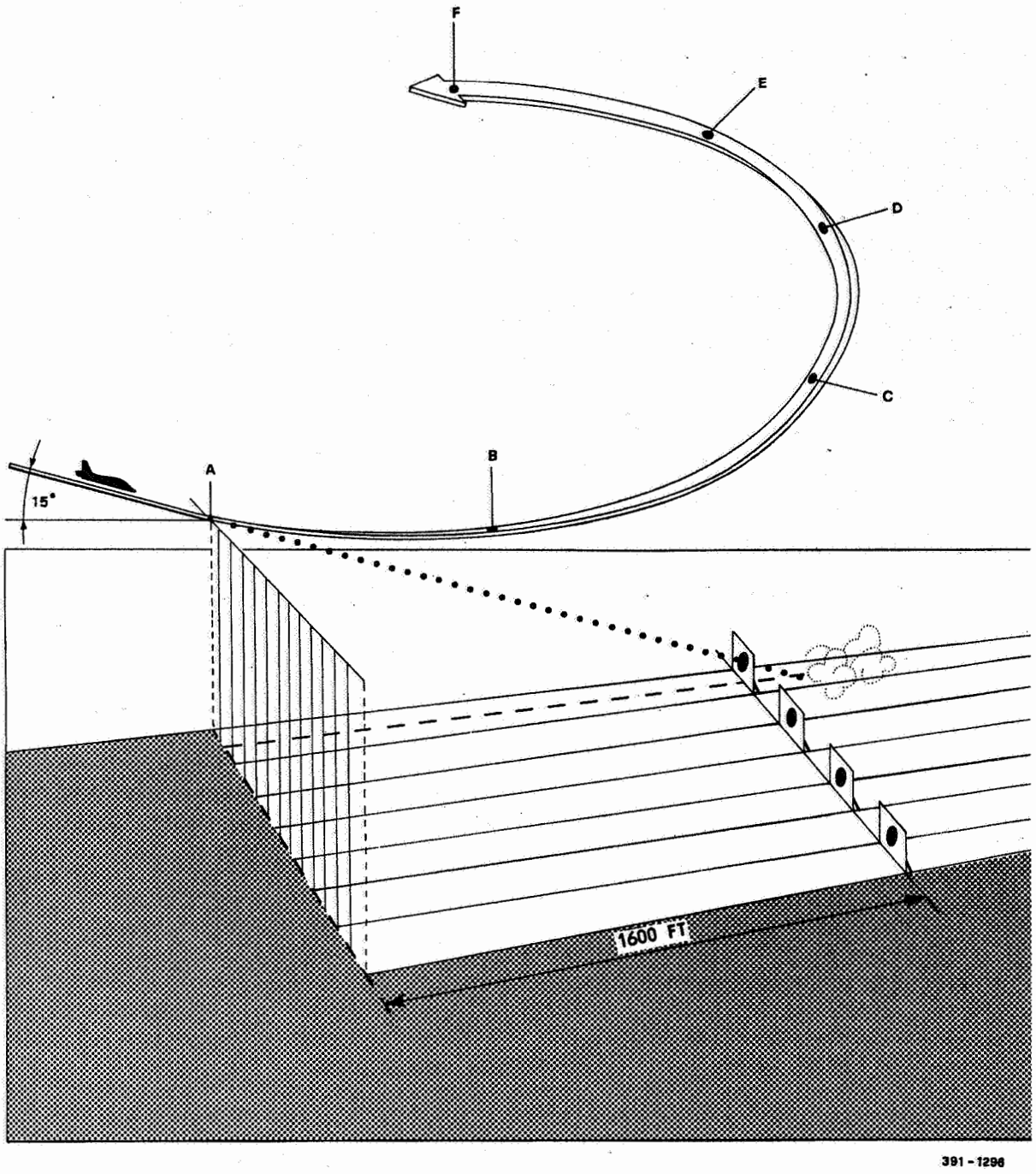
c. Low Angle Strafing Techniques (fig. 14-21 and 14-22)

(1) The flight leader calls to set up the switches and sights for low angle strafing: you have to comply with.

(2) Attain a downwind leg altitude and adjust the power to maintain 300 KIAS (88% RPM). The flight leader will establish the base leg correct position and it is important that you place your base leg in the same position. Maintain 300 KIAS and 2200 ft altitude on the base leg.
Before turning final, make the normal radio call giving range in use and panel color. After completing the radio call, set power to 94% RPM.
Begin a level turn onto the final, and in order to achieve the angle of dive desired for the pass, no altitude should be lost until the nose of the aircraft is approximately three-fourths of the way around the turn. A poorly executed entry turn will decrease your ability to achieve the desired firing conditions. Roll out of the turn with the target in the windscreen. Upon completion of the turn, the pipper is placed at the six o'clock position to the target, so that you will not fly a humped path to keep the pipper on the target as you approach firing range. The pipper will be moved smoothly towards the target as the range decreases.

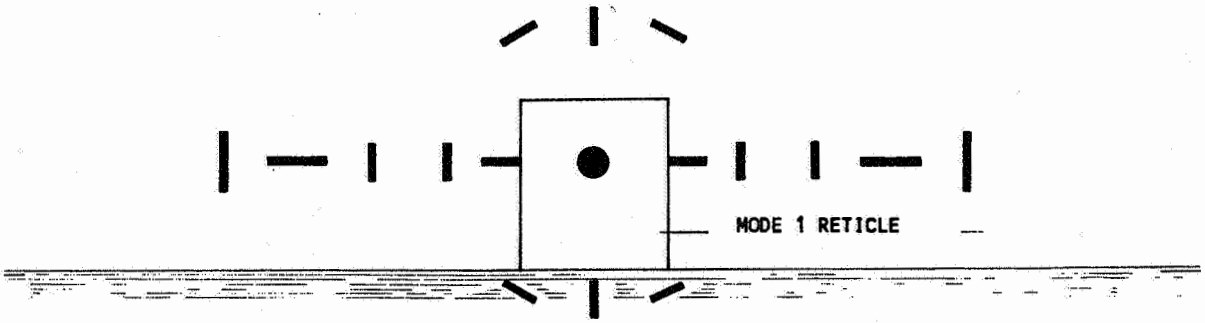
(3) As you reach the desired open fire range 1750 ft (2200 ft for guns strafe) in a non-wind condition, the pipper should be on the bulls--eye of the target. The most accurate method of recognizing the open fire range is by comparing the size of the pipper with 36-inch bulls-eye on the target (fig. 14-23).
The foul line is normally marked on the ground, but since the intense concentration necessary to hold a good aiming point takes all of your attention, you should not try to use the foul line for range estimation.

(4) When you have achieved the proper sight picture, fire a short burst and begin your recovery. The firing airspeed should be 380 kt, and the minimum recovery altitude is 100 ft above the ground. If you open fire at 1750 ft (2200 ft for guns strafe) and fire a short burst, there is no danger of firing past the foul line.
There is no restriction on the maximum "open fire" range, but it must be remembered that the greater the range, the greater the bullet dispersion

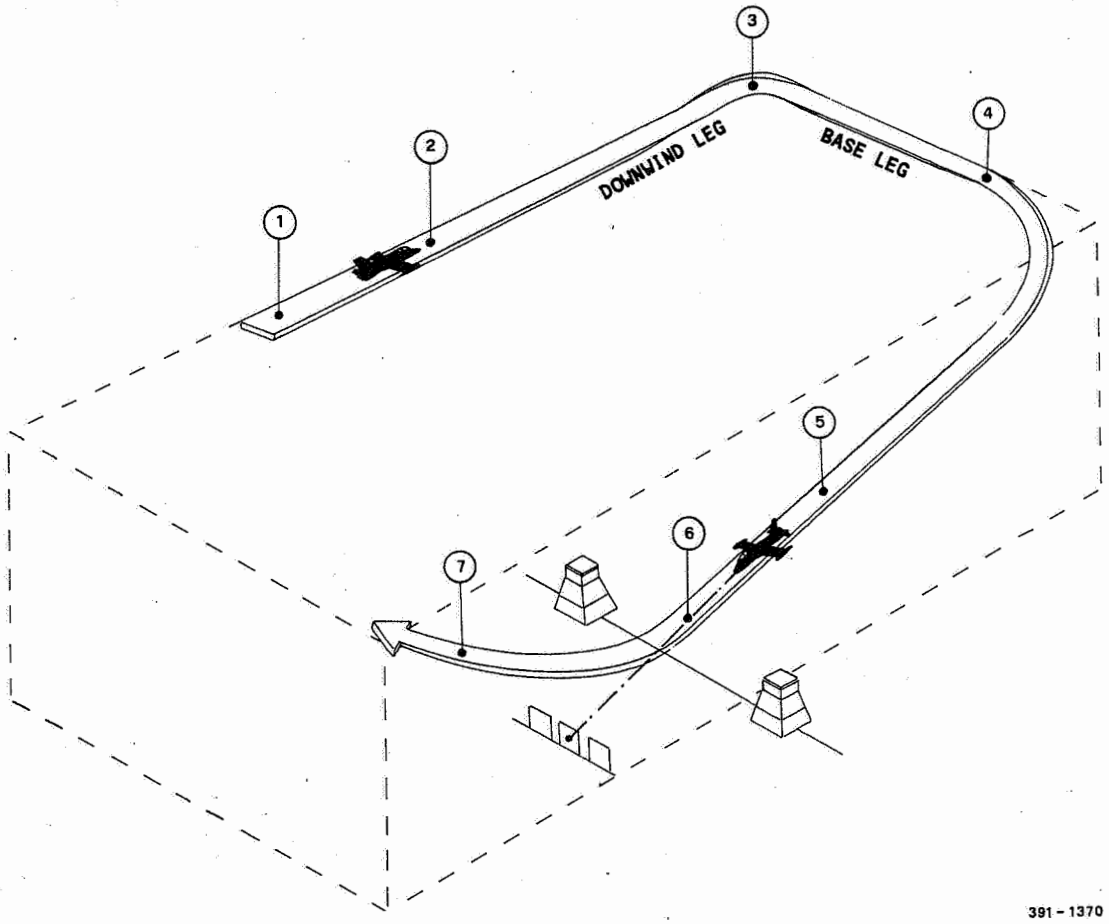


THE PILOT IS FIRING WITH 15° DIVE ANGLE; HE MUST DISCONTINUE FIRING AT POINT A OR BEFORE, VIZ. OVERHEAD THE FOUL LINE; HE MUST THEN IMMEDIATELY START A PULL-UP UNDER A LOAD FACTOR OF AT LEAST 4 G.
ONLY AFTER RAISING THE NOSE ABOVE THE HORIZON (B), HE WILL START A CLIMBING TURN; PASSING THROUGH POINT C WITH 45° BANK, AFTER 45° OF TURN AND 45° NOSE-UP. AT 90°, MAX. BANK ANGLE WILL BE 60° (D), AFTER 135° TURN, BANK ANGLE WILL BE 45° (E) AND ANGLE OF ATTACK 20°, LEVEL-OFF MUST BE AT 180° (F).

Figure 14-21. Low Angle Strafing With Gun

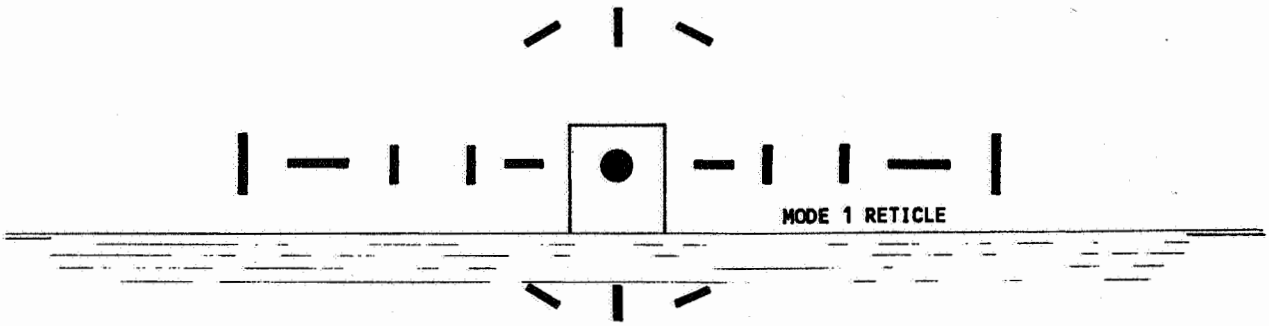


AT 1500 FT SLANT RANGE, RETICLE APPEARS AS SHOWN IN THE FIGURE. HORIZONTAL AND LOWER VERTICAL STROKES ARE TANGENT TO BOARD.

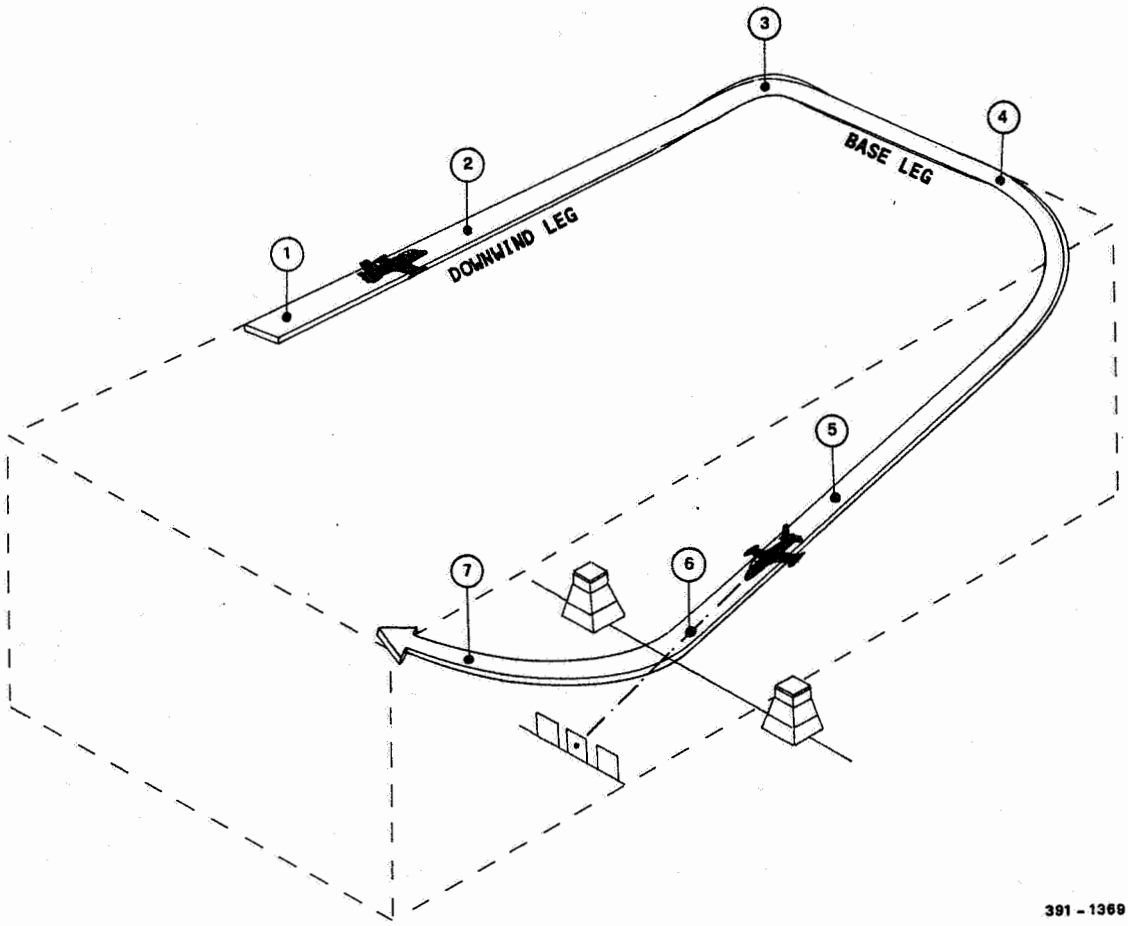


1. GUN PUSH-BUTTON LIGHTS DEPRESSED; GUNSIGHT AT MODE 1
2. 2200 FT AGL, 88% RPM, 300 KIAS
3. BASE LEG AT 8200 FT DISTANCE, 88% RPM, 300 KIAS
4. "IN", RAISE "MASTER ARMT" SWITCH, ENGINE SETTING 90 TO 95% RPM, DIVE TO 15°
5. OPEN FIRE AT: 1750 FT SLANT RANGE, 360 KIAS, 15° DIVE ANGLE, 1/2 SEC BURST
6. CEASE FIRE AT 1200 FT (FOUL LINE) AND IMMEDIATELY PULL-UP
7. PITCH UP BEFORE STARTING TURN

Figure 14-22. Low Angle Strafing Technique With Machine Gun



AT 2200 FT SLANT RANGE, THE RETICLE APPEARS AS IN THE FIGURE. THE BOARD IMAGE APPEARS AS WIDE AS 3/4 OF DISTANCE BETWEEN RETICLE HORIZONTAL STROKES.



1. GUN PUSH-BUTTON LIGHTS DEPRESSED, GUNSIGHT ON MODE 1, DEPRESSION AS REQUIRED
2. 2200 FT AGL, 98% RPM, 300 KIAS
3. BASE LEG AT 8200 FT DISTANCE, 88% RPM, 300 KIAS
4. "IN", RAISE "MASTER ARMT" SWITCH, ENGINE SETTING 90 TO 95% RPM, DIVE TO 15°
5. OPEN FIRE AT: 2200 FT SLANT RANGE, 360 KIAS, 15° NOSE DOWN, 1/2 SEC BURST
6. CEASE FIRE AT 1600 FT (FOUL LINE) AND IMMEDIATELY START CLIMBING
7. PITCH UP THE AIRCRAFT BEFORE STARTING TO TURN

Figure 14-23. Low Angle Strafing Technique With Gun

and gravity drop, thus decreasing your accuracy. If you fire closer than the foul line there is danger of flying into the target, making a low pull--out and mushing into the ground, overstressing the aircraft and/or damaging the aircraft by a ricochet.
The most effective method of wind correction is to aim the pipper into the crosswind at a rate of one-half mil per knot of crosswind. Observe the results of your first firing pass and make necessary correction. Place the pipper into the wind when you first roll out on the final and allow it to drift, so that by the time you are at firing range, your sight will be at the desired aiming point.

(5) Variations from the standard firing conditions will alter the impact point in the following manner.

- OVERSPEED
  Overshoots the target
- UNDERSPEED
  Undershoots the target
- FIRING OUT OF RANGE
  Undershoots the target.
- FIRING IN TOO CLOSE
  Overshoots the target.
- DIVE ANGLE OVER 20°
  Overshoots the target.
- DIVE ANGLE UNDER 20°
  Undershoots the target
- POSITIVE "g"
  Undershoots the target
- NEGATIVE "g"
  Overshoots the target.
- SKID
  Line error in the direction of the ball.

Observe the impact point on the ground, analyze the pass and make the necessary corrections in your next pass to put the entire burst through the target.
The recovery from the strafing pass is much like the one used for skip bombing: pull smoothly up until 40° above the horizon, before commencing the turn to the downwind leg. If recovery minimum are observed there will be little tendency to overstress the aircraft.

9. ROCKETRY

a. Introduction

Rocket missions are normally run in conjunction with the high angle strafing missions. In this case the rockets will always be fired first and the remainder of the mission will be spent high angle strafing.
Four FFAR, inert head will be carried on each mission. A sufficient number of rocket passes will be made for you to fire the rockets before the strafing passes are begun. When carrying rockets, it should be remembered that flaps are not lowered until the rockets have been armed. Since all other phases of the mission up to the pattern itself are the same on all air-to-ground mission, they will not be repeated in this chapter.

b. Pattern Data

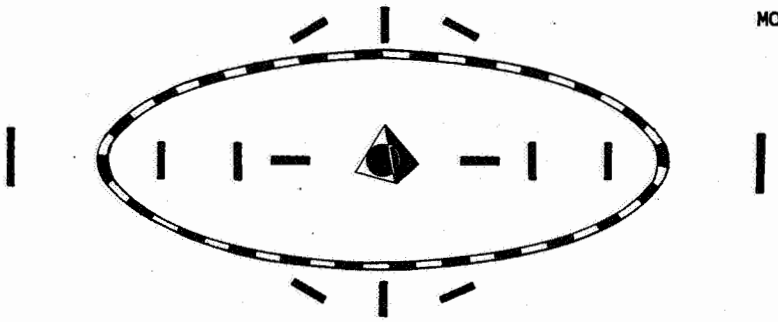
(1) Base leg altitude: 4000 ft AGL
(2) Base leg airspeed: 250 KIAS
(3) Power setting: 86%
(4) Dive angle: 20°
(5) Slant range: 4100 ft
(6) Firing altitude: 1400 ft AGL
(7) Firing airspeed: 370 KIAS
(8) Climb power setting: 92%
(9) Minimum recovery altitude: 1000 ft AGL.

c. Rocketry Pattern

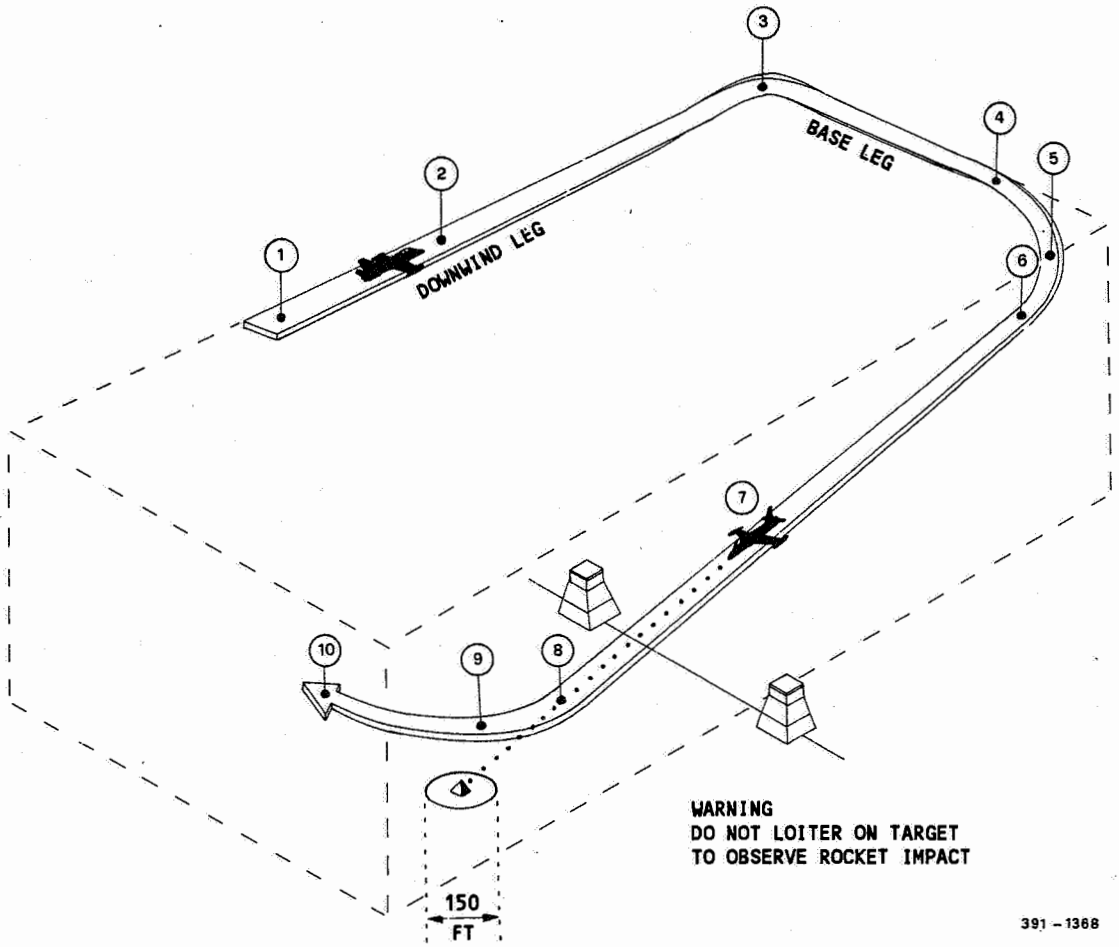
A rectangular pattern will be used.
The spacing pass will be made at rocket firing airspeed (380 KIAS) and each pilot will carefully trim his aircraft at that airspeed. You must increase power to pull up in order to attain the base leg altitude at the proper airspeed. The flight leader will call the flight to set up sight and switches for rocket firing when on the downwind leg. The flight leader will set the base leg in the correct position to insure that the proper dive angle is obtained. In rocketry the base leg is 11 000 ft from the target. You should be certain that the base leg conditions for airspeed and altitude are correct before beginning the turn onto final. Normal spacing will be maintained in the pattern at all times, and the radio call and final power reduction should be made prior to turning onto the final.
The entry is begun by flying the sight from the horizon directly to the vincity of the target. Approximately three-fourths of the turn should be completed before you start to lose altitude. The first pass should be a dry run to allow the pilot to check the trim and firing conditions. You should never remove your left hand from the throttle during the pass as speed brakes may be needed if excess airspseeds are inadvertently attained. Locate all other aircraft in the pattern as you climb on to the downwind leg. While on the downwind, check to see that the rocket sequence switch is set on SINGLE. All changes of switches will be made on the downwind leg, and you should never have your head in the cockpit while turining final or while on the final approach.

d. Rocketry Techniques (fig. 14-24)

On the first downwind leg, when advised by the flight leader to set up switches and sight for rockets, perform the following and sight desired depression, place the rocket switch in the "single" position. Attain the base leg altitude of 3500 ft AGL and turn base leg to the position set by the flight leader, maintaining 250 KIAS. As you approach the turn to final, check the ground control panel, and make the radio call. As you turn final adjust power to 86% RPM.
Make a level turn onto the final, dropping the nose when almost three-quarters through the turn. Bring the sight directly to the vicinity of the target, placing the pipper slightly below the target and letting it "walk-up" as the airspeed increases and range decreases.
On a correct rocket pass with the speed of the aircraft rapidly increasing and the slant range decreasing, the sight will "walk-up" to the bulls-eye and arrive there just as you reach the firing point. Usually, you will fly a curve and will find that it may require slight forward pressure on the



AT 1400 FT SLANT RANGE, WITH A 20° DIVE ANGLE, THE RETICLE APPEARS TO BE SUPERIMPOSED ON THE TARGET CIRCLE AS SHOWN IN THE FIGURE (MAJOR AXIS 37 MILS, MINOR AXIS 18 MILS).



1. RKT OR DISP PUSH-BUTTON LIGHTS DEPRESSED, GUNSIGHT MODE 2, DEPRESSION ANGLE AS REQUIRED
2. APPROX. 86% RPM, 250 KIAS, 4000 FT AGL
3. HORIZONTAL DISTANCE 11000 FT (3300 M), 400 FT AGL
4. ENGINE SETTING 92% RPM, MOVE "MASTER ARMT" SWITCH UP, CALL "IN"
5. STABILIZE DIVE ANGLE AT 20°
6. 3500 FT LEAVE TURN
7. FIRING CONDITIONS: DIVE ANGLE 20°, 370 KIAS, SLANT RANGE 1400 FT, ALTITUDE 1400 FT AGL
8. MINIMUM HEIGHT FOR PULL-UP 500 FT AGL
9. PITCH UP IMMEDIATELY AFTER ROCKET FIRING, ADVANCE THROTTLE TO 98% RPM
10. CLIMB TO 4000 FT AGL

Figure 14-24. Technique for Rocket Firing (Practice Rockets)

stick to hold the pipper on the bull at time of firing. Trimming your aircraft for the firing conditions during your first dry run will minimize this effect and increase the effectiveness of your pass.
As the pipper approaches the bull, check the reticle size and compare it with the 150 ft circle on the ground. As the reticle becomes superimposed on the target circle, you are at the correct slant of 4100 ft. If your aiming point is correct, fire the rocket.
After you have fired your rocket, immediately commence your pull out, as the minimum recovery altitude is 500 ft. As soon as the nose of the aircraft is well above the horizon apply sufficient power and start your climbing turn to the downwind leg. The Range Officer will call your hits as soon as they have been plotted. All calls received from the Range Officer must be acknowledged. You should analyze the results of each pass and correct any errors in aiming point and firing conditions to improve your hits.
As you roll out in the downwind leg, check that the armament panel is properly set for the next rocket to be fired.
If any rockets do not fire, continue to fire the remaining rockets. Dive angle, slant range and airspeed are the most important variables in rocketry, but other causes can affect the trajectory of the rocket. Varying any of these conditions will cause an error. Factors that affect the rocket at the time of firing are listed below:

- OVERSPEED
  Overshoots the target.
- UNDERSPEED
  Undershoots the target.
- FIRING OUT OF RANGE
  Undershoots the target.
- FIRING IN TOO CLOSE
  Overshoots the target.
- DIVE ANGLE OVER 30°
  Overshoots the target.
- DIVE ANGLE UNDER 30°
  Undershoots the target.
- POSITIVE "g"
  Undershoots the target.
- NEGATIVE "g"
  Overshoots the target.
- SKID
  Line error in the direction of the ball.

On each rocket pass, correct for the errors (if any) that you made on the last pass. In a cross wind your attack should be planned so that at the instant the rocket is fired, the pipper is displaced one mil per knot into the crosswind. Begin the recovery immediately after firing: if you delay to see where the rocket hits, your pull-out will be below the 500 ft minimum.

10. HIGH ANGLE STRAFING

a. Introduction

High angle strafing should be normally conducted in conjunction with rocketry missions. Armament load for high angle strafing should be 180

rounds of 0.50 in. caliber or caliber 30 mm ammunition, loaded 90 rounds per gun in two guns. Strafing will be done after the rockets have been fired. Since all phases of the mission up to the traffic pattern itself have already been covered, they will not be repeated in the chapter.

b. Pattern Data

(1) Base leg altitude: 8000 ft AGL.

(2) Base leg airspeed: 170 KIAS.

(3) Power setting at firing: 80%.

(4) Dive angle: 45°.

(5) Release altitude: 3000 ft.

(6) Slant range: 4300 ft.

(7) Firing airspeed: 380 KIAS.

(8) Climb power: 90%.

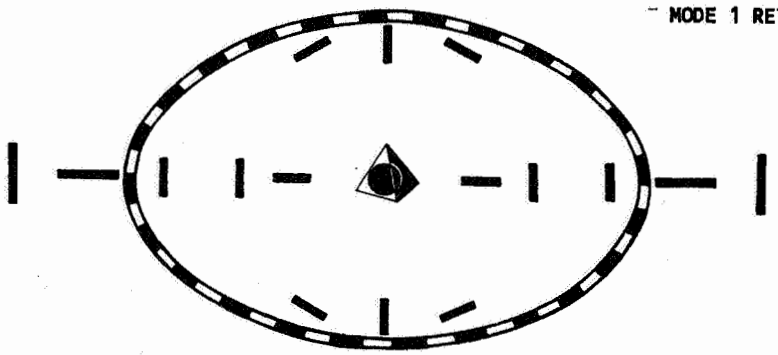
(9) Minimum recovery altitude: 1000 ft AGL.

c. High Angle Strafing Pattern

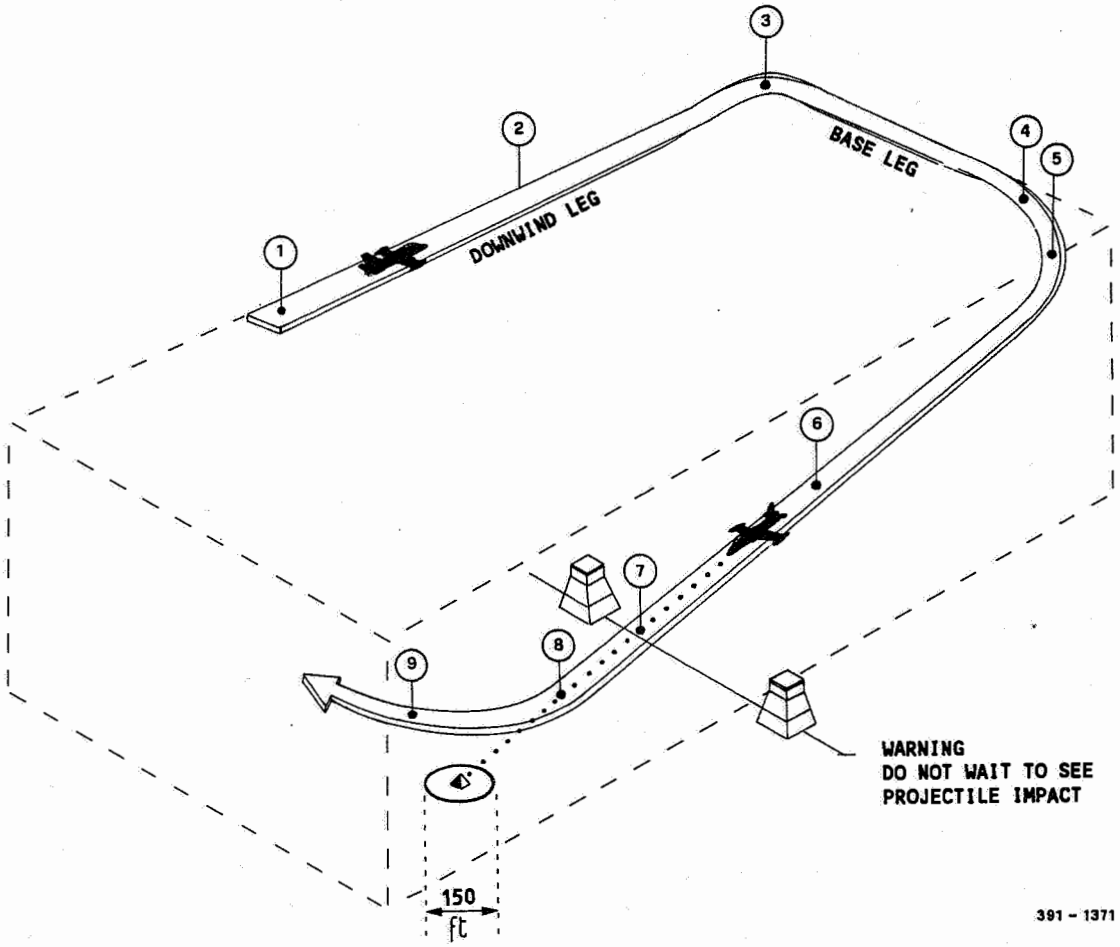
The flight leader will bring the flight across the range in loose echelon formation on a spacer pass, and each member will break into the pattern on three second intervals. Power must be added to reach the base leg altitude at the proper airspeed. As the flight leader reaches the downwind leg, he will call the flight to set-up switches and sights for strafing. The flight leader will establish the base leg at the proper position, and all pilots will strive to maintain this position, in order to attain the proper dive angle. For high angle strafing, the base leg is 9500 ft horizontally from the target.
As each flight member turns onto the final approach to the target, he will observe the control panel on the ground, make his radio call, and make final power adjustment for the strafing run. After achieving the proper sight picture and firing a short burst, a smooth pull-up will be made. As the aircraft nose passes through the horizon, increase power for the climb back to base leg. Begin the turn, in the direction of traffic, only after the aircraft is climbing. While climbing locate all other aircraft in the pattern and establish proper spacing behind the preceding aircraft.

d. High Angle Strafing Techniques (fig. 14-25)

When advised by the flight leader, set-up switches and sight for high angle strafing.
Attain base leg altitude of 8000 ft above the ground and turn onto the base leg at the position set-up by the flight leader. You should maintain 170 KIAS airspeed on the base leg. As you approach the turn to final, check the color of the ground control panel and make your radio call. As you turn onto the final, adjust power to 90%.
Use a wing-over type of turn onto the final and pull the nose of the aircraft down to a point just below the target. This places the pipper well below the target and avoids the necessity of pushover to obtain the sight picture after aligning the target on the final approach. As the airspeed increases and the slant range decreases, allow the sight to move up to the target. As the sight approaches the target you will notice that the reticle is larger than the 150 ft circular target on the ground. Fly the sight pipper up until it is directly over the bulls-eye, and at this time you should be approaching the correct slant range. Hold the pipper on



AT 4300 FT SLANT RANGE AND 45° DIVE ANGLE, THE RETICLE IS SUPERIMPOSED ON TARGET CIRCLE AS SHOWN IN THE FIGURE (MAJOR AXIS 35 MILS TANGENT TO HORIZONTAL STROKES AND MINOR AXIS 25 MILS).



1. GUN PUSH-BUTTON LIGHTS DEPRESSED, GUNSIGHT MODE 1
2. 8000 FT AGL, 170 KIAS AND 78% RPM
3. HORIZONTAL DISTANCE FROM TARGET 8000 FT, 170 KIAS AND POWER SETTING APPROX. 72% RPM
4. "IN" AND LIFT "MASTER ARMT" SWITCH, POWER SETTING 90% RPM, INCREASING IAS
5. STABILIZE DIVE WITH 45° DIVE ANGLE
6. OPEN FIRE WITH: 45° ANGLE, 4300 FT SLANT RANGE, 3000 FT AGL HEIGHT
7. FIRE SHORT BURST AND IMMEDIATELY PULL-UP
8. MINIMUM HEIGHT 1000 FT AGL
9. PITCH UP THE AIRCRAFT BEFORE ENTERING TURN; 98% RPM

Figure 14-25. Technique for High-Angle Strafing

the bulls-eye and as the reticle superimposes itself to the target you are in range.
Sufficient rounds should be fired so that the impact will raise enough dust for the plotters to score the hit, however do not hold the dive so long that you descend below the 1000 ft minimum altitude on pull-out. You should fire at 4300 ft slant range and 380 KIAS airspeed. As you pull the nose of the aircraft above the horizon, increase the power to 90% for the climb back to base leg altitude. Be sure that the aircraft is definitely climbing before beginning the turn in the direction of traffic. Locate all aircraft in the gunnery pattern as you climb to the base leg altitude and gain proper spacing.
When performing high angle strafing the sight picture is used to determine the slant range. Both dive angle and airspeed in excess of that required causes an overshoot condition. In a no wind condition, firing in a 45° dive, at 380 KIAS, and at 4300 ft slant range, you will hit the bulls-eye provided the sight pipper is on the target. Varying any of these conditions will cause an error. Effects of these conditions are as follows:

- OVERSPEED
  Overshoots the target.
- UNDERSPEED
  Undershoots the target.
- FIRING OUT OF RANGE
  Undershoots the target.
- FIRING IN TOO CLOSE
  Overshoots the target.
- DIVE ANGLE OVER 45°
  Overshoots the target.
- DIVE ANGLE UNDER 45°
  Undershoots the target.
- POSITIVE "g" WHILE FIRING
  Undershoots the target.
- NEGATIVE "g" WHILE FIRING
  Overshoots the target.
- SKID WHILE FIRING
  Line error in the direction of the ball.

The Range Officer will call each hit in footage distance from the bulls-eye and indicate the clock position as soon as it is plotted. Acknowledge each call and then analyze your pass to correct your firing conditions and aiming point. If you have an error, make a correction for it, on the next pass. Put your base leg in the proper place to insure that you have a 45° dive angle. Find the power setting that will give you the correct airspeed and use it on each pass. Your slant range is determined by your sight picture: so be certain that you have the correct sight picture when firing.
Good trim techniques and good tracking before firing will eliminate the necessity to hold positive or negative "g" while firing. If there is a wind on the range, make a correction for it, by using 1/2 mil per kt of lead into the crosswind.

11. HIGH ANGLE DIVE BOMBING

a. Pattern Data

(1) Base leg altitude: 4500 ft AGL.

(2) Base leg airspeed: 250 KIAS.

(3) Power setting: 84%.

(4) Dive angle: 30°.

(5) Slant range: 4000 ft.

(6) Drop altitude and airspeed: 2000 ft AGL - 340 KIAS.

(7) Climb power: 98%.

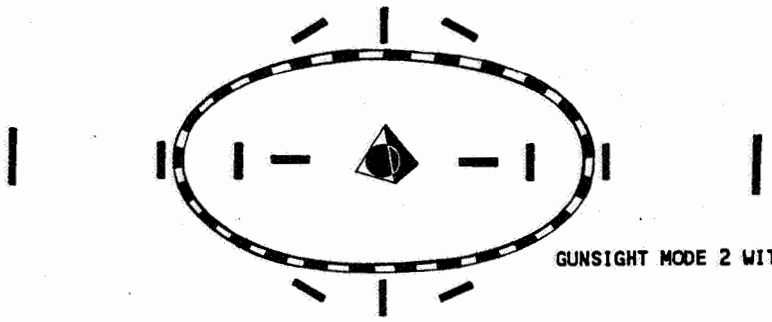
(8) Minimum recovery altitude: 1000 ft AGL.

b. High Angle Dive Bombing Pattern

Rectangular traffic patterns will be used.
The flight leader will bring his flight across the range in loose echelon on a spacing pass, and each member will break up into the pattern at three second intervals. 98% power will be used to climb to base leg altitude. The spacing pass will be made at bomb release airspeed to allow for trimming the aircraft.
As the flight leader reaches to downwinds leg, he will call the flight to set-up switches and sights for bombing. The flight leader will establish the correct base leg position and each pilot will strive to maintain this position. In high angle dive bombing, the base leg is 9000 ft horizontally from the target for the 30° dive. As each flight member turns onto the final approach to the target, he will observe the control panel on the ground and make his radio call. He will then adjust the power for his bombing run, remembering to reduce power to prevent excessive speeds. After achieving the proper sight pictures and releasing the bomb, a smooth pull-up will be started. As the nose of the aircraft passes through the horizon, increase the power to 98%. Begin a turn in the direction of traffic only after the aircraft is climbing. While climbing locate all other aircraft in the pattern and establish proper spacing.

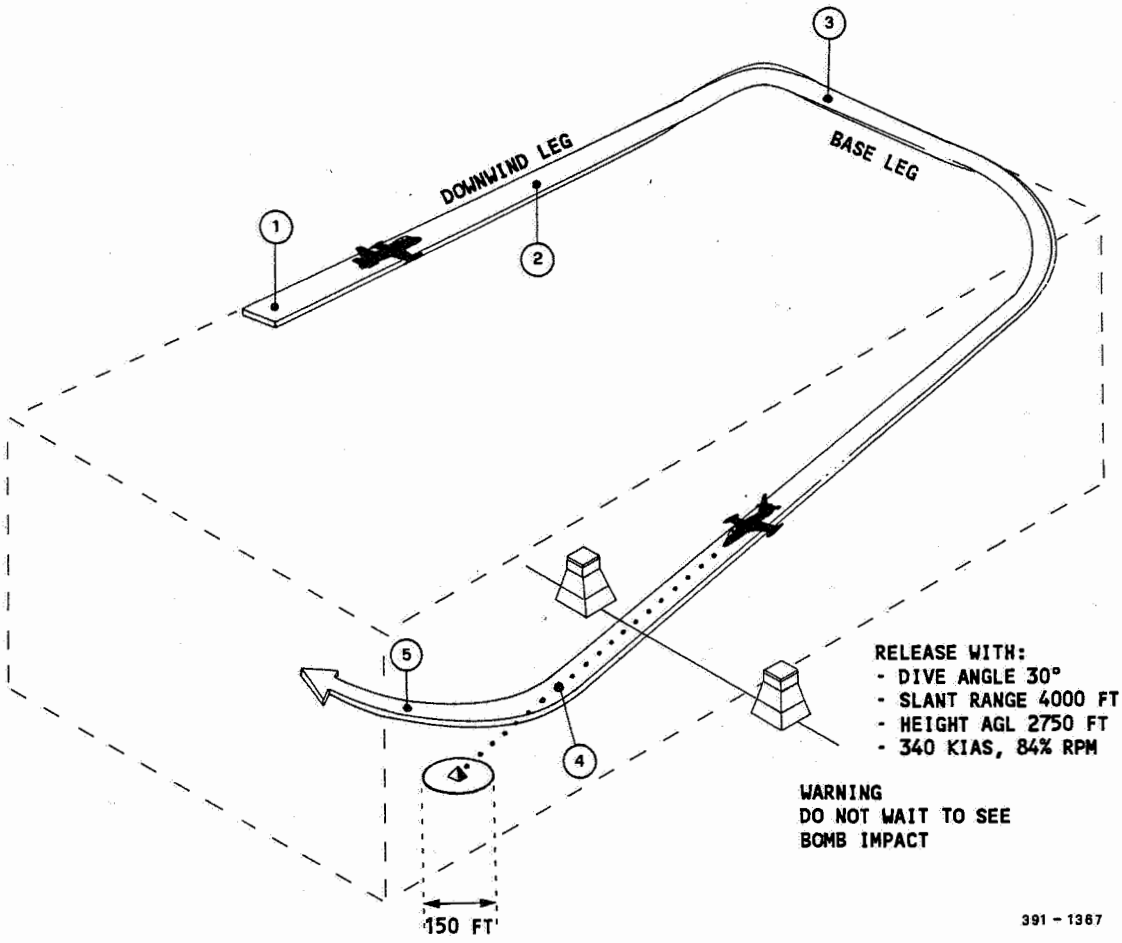
c. High Angle Dive Bombing Techniques (fig. 14-26)

When advised by the flight leader set up switches and sight for bombing. Attain a base leg altitude of 4500 ft AGL and turn onto the base leg at the proper position. When the base leg is in the proper position you should be able to look over the side of the cockpit and see the target on the ground. As you approach the turn to final, check the color of the ground control panel and make your radio call. You will have to reduce power to maintain 240 KIAS on base leg and should have the power back to 84% when turning on the final approach, to prevent excessive diving speed. As you start your turn onto final, check the range control panel and make your radio call. This turn should be executed as a wing over type turn, pulling the nose of the aircraft down to the target. Because of the depressed sight this places the pipper well below the target and prevents the necessity of pushover to obtain the desired sight picture after aligning with the target on the final approach.
As the slant range decreases, you should fly the pipper up to the target. The pipper movement should be such that it arrives on the bulls-eye just prior to reaching the desired slant range and altitude.
The "pendulum effect" of the depressed sight will probably cause you to overcorrect, until you have learned how much turn will give you the amount of correction you desire.



GUNSIGHT MODE 2 WITH ROLL COMPENSATION

AT 4000 FT SLANT RANGE AND DIVE ANGLE OF 30°, THE RETICLE IS SUPERIMPOSED ON TARGET CIRCLE AS SHOWN IN THE FIGURE. MAJOR AXIS 27 MILS NEARLY TANGENT (INSIDE) THE VERTICAL STROKES.



1. APPROX. 84% RPM, BOMB PUSH-BUTTON LIGHT DEPRESSED (OR DISP) GUNSIGHT MODE 2, DEPRESSION AS REQUIRED
2. 4500 FT AGL, 84% RPM, 250 KIAS
3. "MASTER ARMT": RAISE, DISTANCE FROM TGT 9000 FT
4. MINIMUM ALTITUDE DURING PULL-UP 1000 FT AGL, PITCH UP BEFORE STARTING TURN
5. CLIMB WITH APPROX. 98% RPM

Figure 14-26. Technique for Dive Bombing

Once you have made your correction and the "pipper" is tracking smoothly along the ground toward the target, check the reticle size as compared with 150 ft circle of the target on the ground. When the reticle superimposed on the major axis of the 150 ft circle your slant range is 4000 ft. At this point, with the pipper on this bulls-eye, depress the bomb release button, and begin your pull-out.
With a 4000 ft release slant range, a 4 to 5 "g" pull-out will allow you to complete your recovery above the minimum altitude of 1000 ft. When the nose of the aircraft is well above the horizon, apply full power and start your turn to be downwind leg.
Effect of varying the bomb release conditions are as follows:

- OVERSPEED
  Overshoots the target.
- UNDERSPEED
  Undershoots the target.
- RELEASE OUT OF RANGE
  Undershoots the target.
- RELEASE IN TOO CLOSE
  Overshoots the target.
- DIVE ANGLE OVER 30°
  Overshoots the target.
- DIVE ANGLE UNDER 30°
  Undershoots the target.
- POSITIVE "g" DURING RELEASE
  Undershoots the target.
- NEGATIVE "g" DURING RELEASE
  Overshoots the target.
- SKID DURING RELEASE
  Line error in the direction of the ball.

The Range Officer will call each bomb hit as soon as it is plotted. He will call it in footage from the bull's-eye in the clock position and you will acknowledge each transmission. As you climb back to the base leg you should analyze the pass, determine the errors made, and make necessary corrections. Your dive angle is controlled by your base leg position, and altitude, as these factors are very important in setting up your attack. Your airspeed is controlled by your power setting and after the first pass, using the approximate setting given, you should know just how much power is necessary to obtain 340 KIAS in the aircraft you are flying. Slant range at release point is controlled by sight picture, if you have the proper sight picture when you release, you will be releasing at 4000 ft slant range. Good trim technique and good tracking before release, will eliminate the necessity of holding positive of negative "g" at the release point.
The Range Officer will notify the flight of wind condition on the range. Wind correction the bombing is two mils per kt of crosswind. You should adjust your aiming into the wind by moving the aiming point around the target into the crosswind, and keeping it the same distance out from the bulls-eye. You will note that this bombing system more nearly simulates conditions you will have in combat. You no longer need a 150 ft circle to estimate slant range, and the only advance information you need is the target elevation. Simple computations for dive angle, aiming point altitude and sight setting can be made prior to the combat mission.
In Figure 14-27 and 14-28 are shown the "MEMORANDUM" to write the relevant data concerning practice A/A and A/G missions.

WRITE HERE THE RELEVANT DATA CONCERNING PRACTICE AIR-TO-AIR MISSIONS WITH DIFFERENT TYPE OF WEAPONS									
AIR-TO-AIR	EVENT	–	MACHINE GUN	GUN					
	ARMAMENT	–	12.7 mm	30 mm					
	TARGET ALTITUDE	ft							
	PERCH ALTITUDE	ft							
	PERCH POWER	%							
	PERCH IAS	kt							
	ENTRY POWER	%							
	ENTRY IAS	kt							
	REVERSE TURN IAS	kt							
	FIRING IAS	kt							
	FIRING TAS	kt							
	SIGHT SETTING	mils	AUTO	AUTO					
	CLIMB OFF IAS	kt							
	CLIMB OFF POWER	%							

Figure 14-27. Memorandum - Training Weapon Release - Air-to-Air

WRITE HERE THE RELEVANT DATA CONCERNING PRACTICE AIR-TO-GROUND MISSIONS WITH DIFFERENT TYPE OF WEAPONS									
AIR-TO-GROUND	EVENT	–	BRD		Rx	GUN 30mm	MAC.GUN 12.7mm.	MK76	
	ARMAMENT	–	MK 106	MK 76	SNIA 2"	POD	POD	PYL	BRD
	SIGHT SETTING	mils							
	BASE LEG ALTITUDE	ft							
	BASE LEG IAS	kt							
	BASE LEG POWER	%							
	DIVE ANGLE	deg							
	RELEASE PWR SET	%							
	RELEASE IAS	kt							
	RELEASE TAS	kt							
	RELEASE ALT AGL	ft							
	RELEASE SLANT RNG	ft							
	MINIM. RECOVERY ALT	ft							
	POWER TO CLIMB	%							
	DOWN WIND LEG IAS	kt							

Figure 14-28. Memorandum - Training Weapon Release - Air-to-Ground

PART FOUR - CHAPTER XIV

SECTION D - FILM ASSESSING

1. FILM ASSESSING

A conscientious assessing program will result in consistently higher gunnery scores, better trained and more proficient aircrews, higher sight in commission rates, and, most important, maximum benefit from each firing and bombing event.
The well-informed pilot uses the gun camera to determine errors in firing range, slant range, dive angle, alignment with the target, and offset release aiming point. During combat, either aerial or ground attack, the gun camera often provides the only method of recording the destruction inflicted by the fighter. Through proper interpretation or assessment of the film taken by airplane cameras, methods of subsequent attack and vulnerable points of enemy targets can be determined. Proper assessment is an invaluable tool for improving proficiency as well as providing intelligence information.
Procedures are included for determination of range, angle-off, and/or dive angle, assessing equipment and chart construction. Descriptions of the various gun cameras and their specific characteristics are not included, since guidance for their operation is supplied in the FM and Teledyne 431045 "MODEL TCS 116-2 CAMERA" Operating and Maintenance Instructions Manual.

2. ASSESSING AERIAL ATTACK FILM

a. General

To assess accuracy of attack against aerial target, the pilot must evaluate three things: range, angle-off, and line error. The procedures for determining these items are in the following paragraphs.

b. Range

Run the film until the first firing frame of the gunnery pass appears. Using calipers, transfer the width of the target image to the aerial attack estimate assessing chart for the type of lens and size of target being used. Lay this width down the vertical axis of the chart from the baseline. See figure 14-29. Compare this assessed range with the desired firing range and note findings. In figure 14-30 are illustrated the two oxis of the A6B tow target.

c. Angle-off

Two methods are commonly used to measure and assess angle-off. In one method, the observable length of the target (fig. 14-31) is measured and this measurement is applied to the assessment chart. The other method involves measurement of a known distance on the target. Again, the measurement is applied to the appropriate assessing chart. Either method is satisfactory. The one to be used should be determined by the fighter weapons officer after considering target size, definition of film, and personal preference. After an assessing chart has been constructed for use with the chosen method, use calipers to measure the

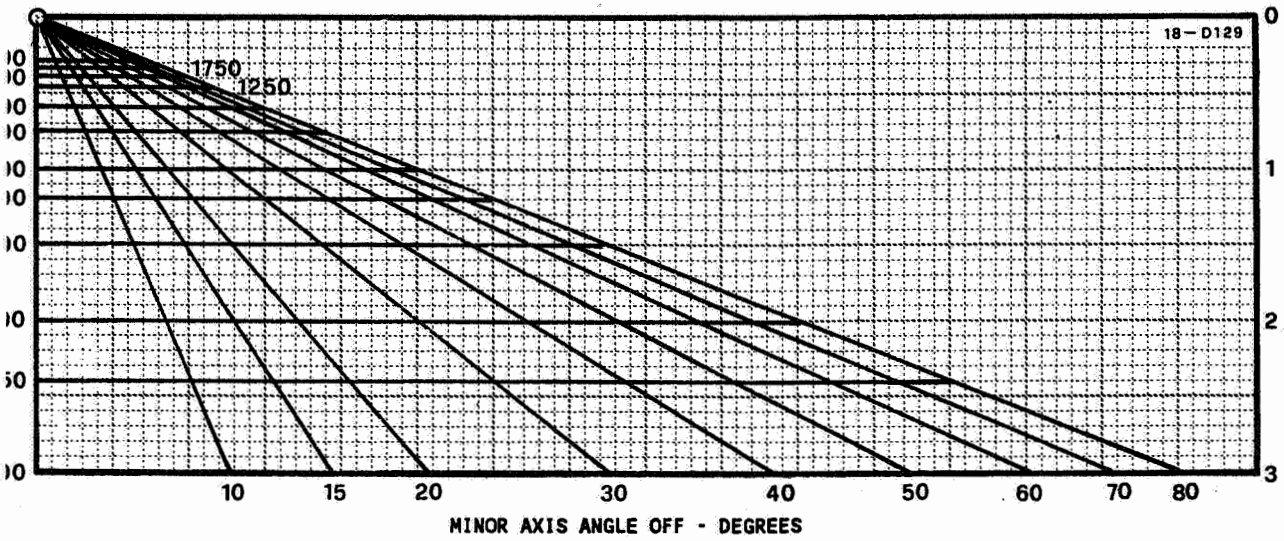


Figure 14-29. Aerial Attack Assessing Chart - A6B Target

foreshortened target dimension. Lay this distance off on the horizontal axis of the chart, with one point of the calipers on the vertical axis at the range figure as previously determined. The other point of the calipers will then fall on or between the angle-off lines which emanate from a point at the maximum range of the chart. Interpolation between these radial lines gives the angle-off.

d. Line Error

The distance, in mils, which the pipper is displaced from the aiming point on the target is known as line error.
This distance is found by measuring the distance, in inches, between the aiming point on the target and the pipper. The line error is this measurement read in mils (1 in. equals 10 mils). Therefore, 1 in. of the pipper displacement would equal about 10 ft of impact error at 1000 ft slant range. Repeat the process at each 2 frame interval.

e. Summary

If more than one firing pass is performed, note assessment information for range, angle-off, and line error for each pass and compare the results.

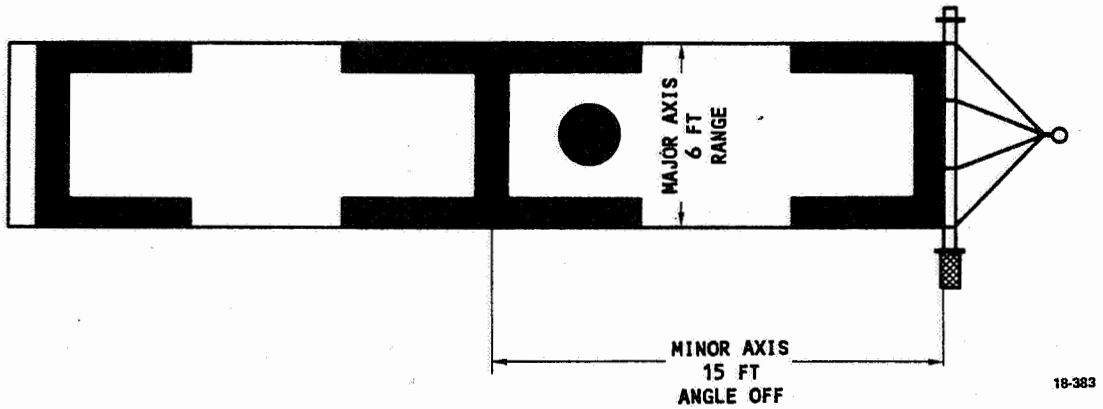


Figure 14-30. A6B Tow Target - Banner Type

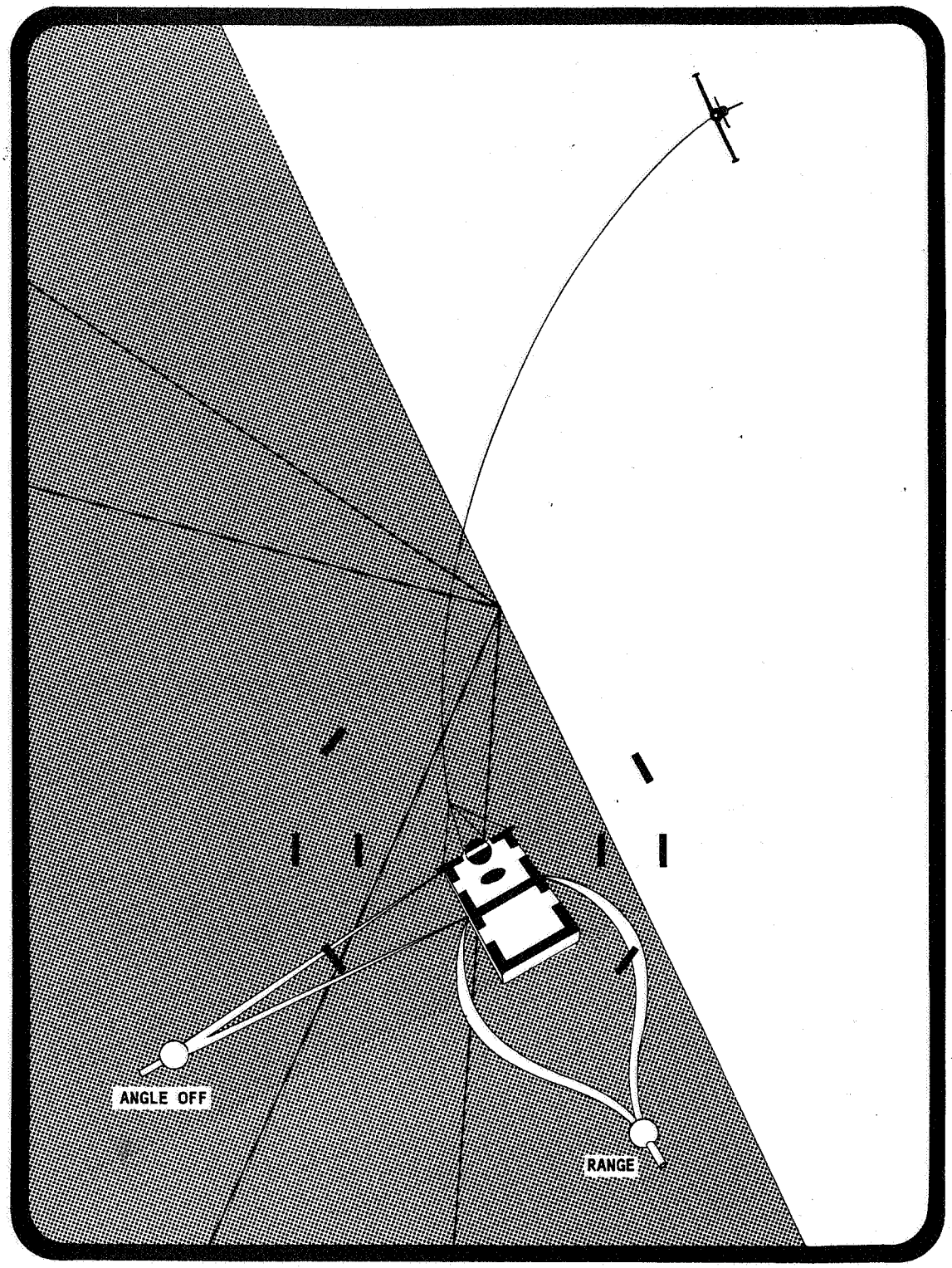


Figure 14-31. Air-to-Air Assessing Frame

Usually one or more consistent discrepancies will become evident. Repeated correlation between studied discrepancies in the assessment room and the in-flight attack will quickly achieve the desired objective: consistency of range, angle-off, and sight picture in the aerial attack.

3. OTHER USES OF ASSESSING CHARTS

Increased emphasis on gun-camera use in simulated attacks against other airplanes has generated a need for a standard measurable index to be used in assessing film obtained on those missions. A study of airplanes can determine which airplane features are suitable for this purpose. For a bomber, the fuselage diameter is determined to be a satisfactory range index. However, the vertical stabilizer of fighter airplanes is found to be a more suitable reference in level attacks during which both the fighter and the target airplanes are in the same plane of reference. With high-side and low-side attacks, the foreshortening effect makes the stabilizer an unreliable index, thus making it necessary to develop special charts for specific attacks.
If attacks are made in the vertical plane on fighter, unit fighter weapons officers can apply formula to construct valid assessing charts.

NOTE

It is possible to select on the target aircraft (fig. 14-32) a 6 ft vertical structure and a 15 ft horizontal structure in order to have the major axis and minor axis of the target aircraft of dimensions equal to those of the A6B banner-target. Consequently the aerial attack assessing charts (fig. 14-29) concerning the banner target can be also used for the target aircraft.

a. Assessing Ground Attack Film

WARNING

Dive bombing or air-to-ground rocket deliveries requires an immediate pull-up after the release and therefore it is not possible to film assess the weapon hit on the ground. Never-

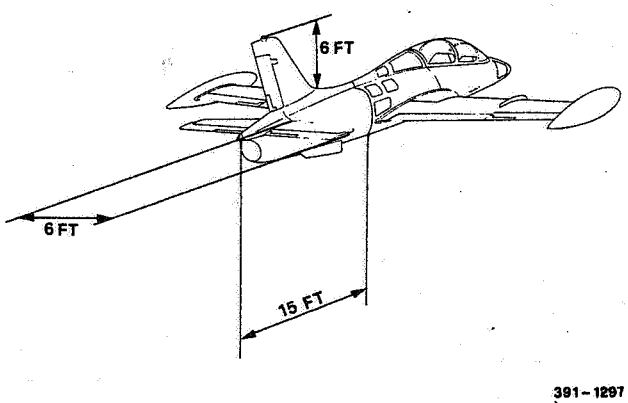


Figure 14-32. MB 339 - Target Aircraft

heless it is always possible to assess the pipper position with respect to target, (line error) the target size, and the dive angle also, at the moment of weapon release. This happens automatically when releasing rockets or bombs.

NOTE

Only the first frame is valid for assessing.

Assessing film of dive-bombing or rocket deliveries requires a knowledge of the target's size and a comparison of its size to the dimensions of the assessed image on an assessing chart. The ground attack assessing chart is constructed with a known proportional relationship to the target's size, hereby permitting determination of the airplane dive angle and firing slant range. The procedures for determining these items are in the following paragraphs.

Run film through the projector until the opening frame of the pass appears. With calipers, measure the major axis - the axis of the target circle perpendicular to the diving airplane path over the ground. See figure 14-33. Lay this measurement off along the horizontal axis of the ground attack assessing chart (designed for use with a camera lens of a specified focal length and for a target of a specified size). This reading gives the slant range in feet. See figure 14-34. Measure the minor axis - the axis of the target parallel to the diving airplane's path over the ground. Transfer this measurement to the vertical axis of the ground attack assessing chart. Place one point of the calipers on the vertical axis at the range figure as previously determined. The other point of the calipers will then fall on or between the angle-off lines which emanate from a point at the maximum range of the chart. Interpolation between the diverging dive-angle lines gives the dive angle in degrees.

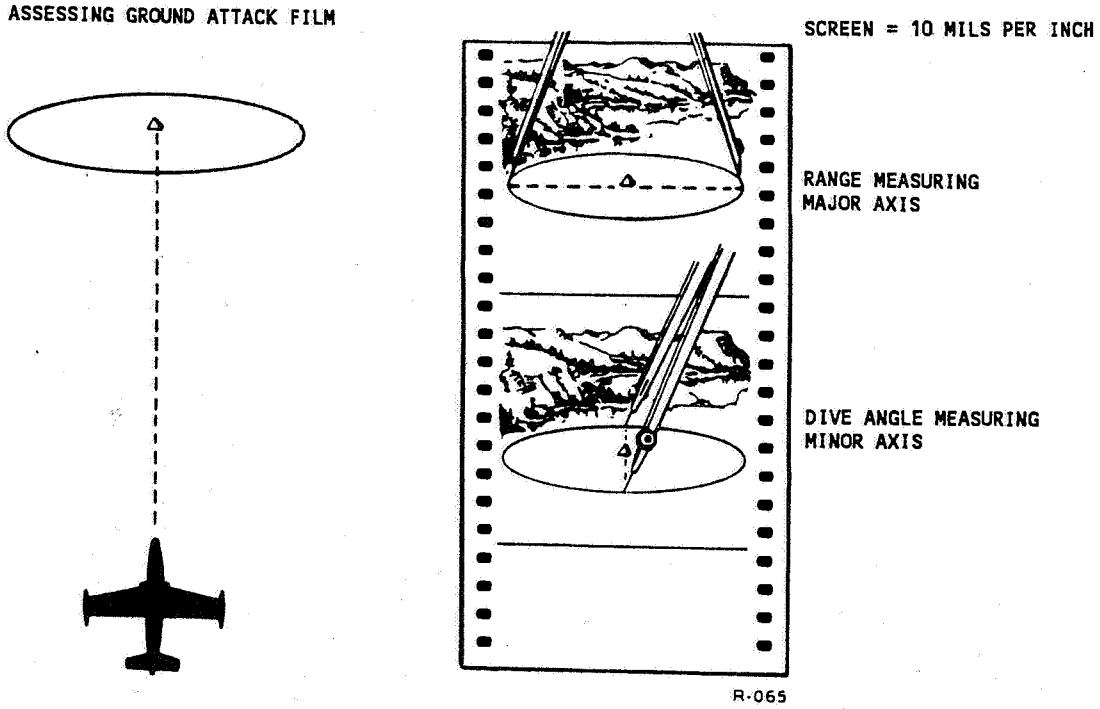


Figure 14-33. Air-to-Ground Attack Assessing Film

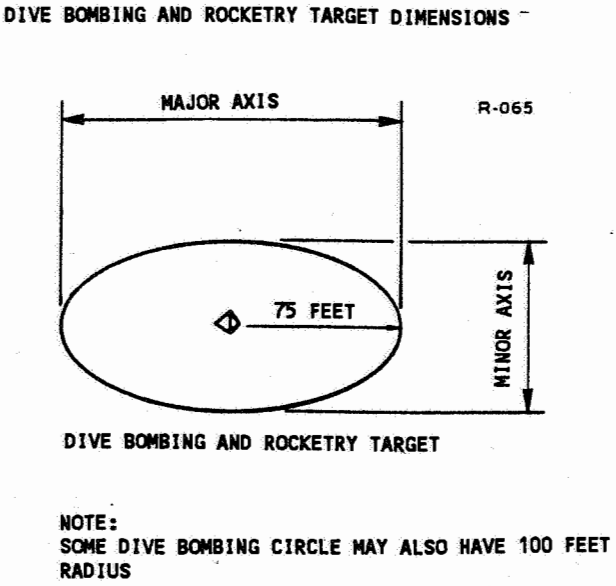


Figure 14-34. Dimensions of Target Circle

4. ASSESSING ROOM EQUIPMENT

The film assessing room should include the following equipment:

- 16 mm motion picture projector.
- Assessing table or workbench upon which to mount the projector.
- Projector screen.
- Calipers.
- Film reels.
- Film rack storage.
- Film assessing charts (fig. 14-35 and 14-36).
- Magazine titling assembly, locally manufactured from a standard gun camera.

5. ASSESSING CHART CONSTRUCTION

This paragraph deals primarily with construction of assessing charts for the 30,4 mm lens (procedures and formulas outlined are applicable to any gun camera lens, but it is necessary to substitute different values for the angle of projection of other lenses and target sizes). Charts presently in use are designed for a projection image with a scale of 10 mils per inch (although larger images would tend to promote accuracy in using the chart, poor film quality produces unacceptably poor target definition). Since the angular projection of the 20,4 mm lens is 247 mils, the arbitrarily selected scale of 10 mils per inch requires that the projector be positioned to achieve a projected frame or image 24,6-inch in height. After this determination, charts are constructed to scale, thus permitting a direct transfer of measurement from the projected image on the screen to the assessing chart (distance from lens to screen is 49,2 in.). See figure 14-37. Computation for chart construction is accomplished in three steps (the third step is used only when angle-off or dive angle must be determined):

- Determine target size, in mils, for a specified range. This may be accomplished by substituting into the formula:

$$\frac{\text{Target dimension} \times 1000}{\text{Range}} = \text{Target size in mils}$$

- Convert target size, in mils, to width in inches. To do this, substitute into the formula:

$$\frac{\text{Target size in mils}}{\text{Mils per inch on screen}} = \text{Width in inches on the screen}$$

- Determine length of the minor axis of the aerial target, bombing circle, or strafe panel, in inches, for the specified range and dive angle. Substitute into the formula:

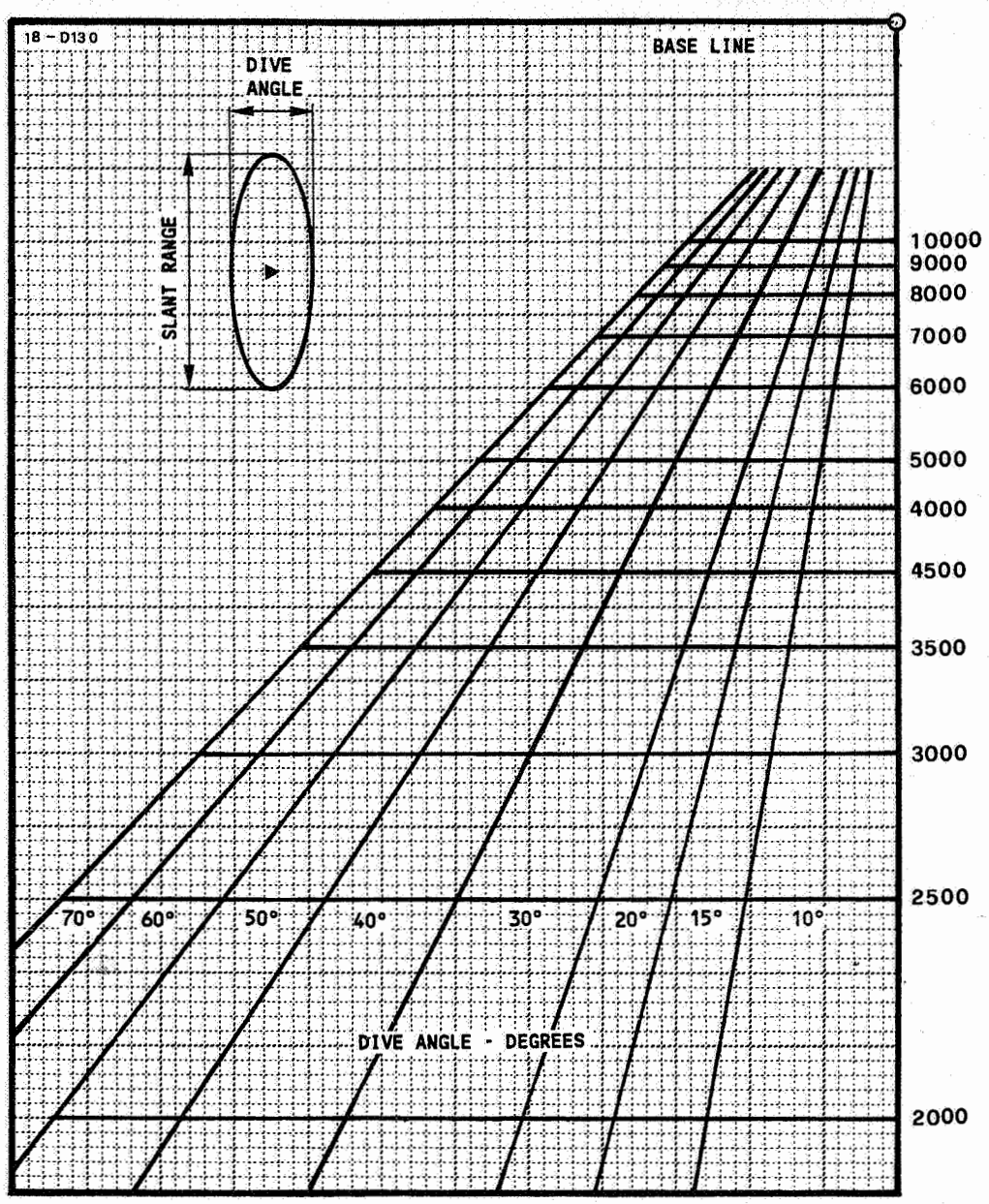
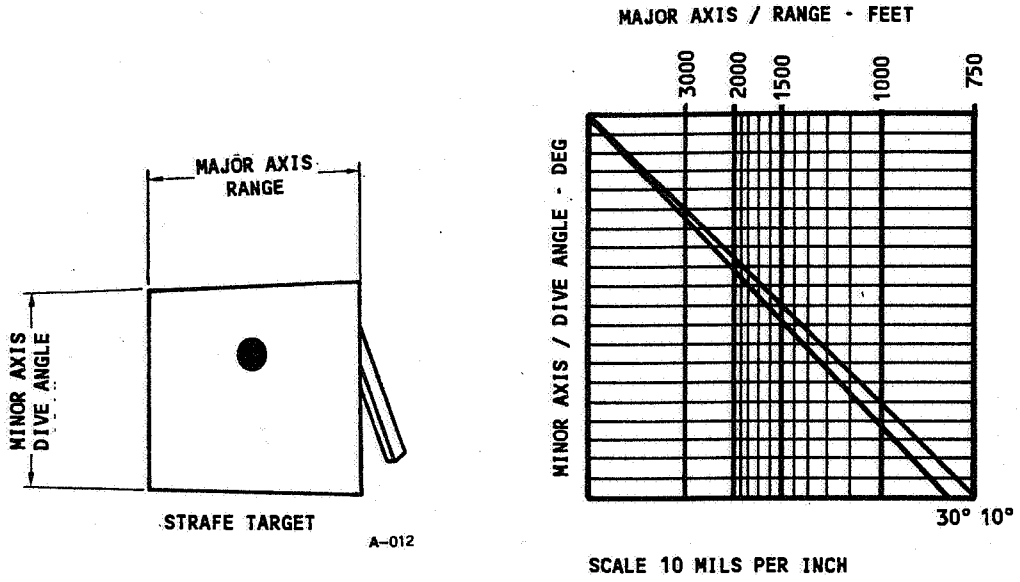


Figure 14-35. Assessing Ground Attack Chart



NOTE: FILM ASSESSING OF DIVE ANGLE IS UNPRACTICAL

Figure 14-36. Assessing Ground Attack Chart Low Angle Strafing

$$\frac{\text{Target size in mils x Sine of dive angle}}{\text{Mils per inch on scren}} = \text{Minor axis in inches}$$

To perform necessary computation and construct an A6B assessing chart, use 6 feet as the target dimension and appropriate selected range. Substitute into the formula in step 1 to determine target size, in mils, for the selected ranges.
At the greater ranges, this chart is likely to produce major errors in measurement because of poor target definition and proximity of the range lines on the chart. Since 10 mils represents 1 in. on the screen, (divide

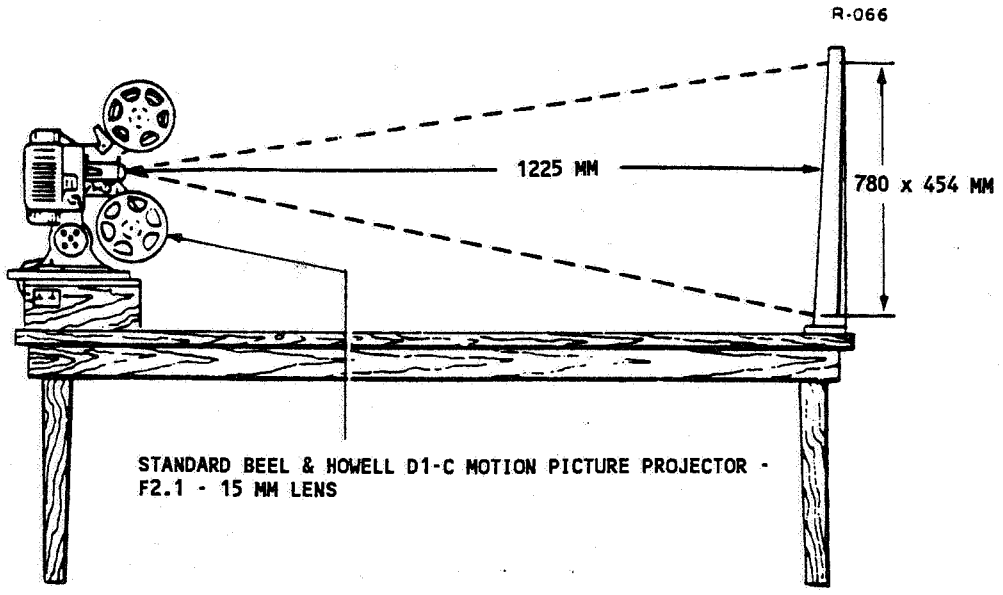


Figure 14-37. Assessing Equipment General Layout

mil-values by 10 to complete step 2). The chart can now be constructed with all measurements taken from the baseline. When film assessing charts are constructed for aerial combat targets, complete step 3. For angle-off measurement, the dimension of a given portion of the fuselage length is the appropriate target length. The size of the portion used will depend upon the type of airplane photographed. (See aerial target in figure 14-32).

To construct a dive bomb chart, use the same procedure to determine range lines; then substitute into the formula for step 3 to compute the length of the minor axis of the bombing circle for various dive angle. Although it will be necessary to compute these for only one selected range (range has a proportional relationship to dive angle), it is wise to check accuracy of work by computing dive angles for at least three ranges. In the construction phase, measurements for fixing the position of range lines must be taken from the baseline. After range lines have been drawn (as shown in fig. 14-36) determine the points of intersection and draw in the dive-angle lines as shown (measurements will be made from the vertical line). The completed chart is shown in figure 14-35.

With chart computation accomplished and the assessing room organized, the role of the weapons officer in the film assessing program is only partially complete. For the film assessing program to be effective, record must be kept of all film taken and assessed. If this is done and film is assessed conscientiously, you can expect to receive a bonus of improved scores and greater overall effectiveness.

NOTE

By using a camera gun with a focal distance f = 30,4 mm (1/10 ft) and for the projection a motion picture projector having a focal distance f = 15 mm the results are as follows:

- On the photogram 1 mil is equal to 1/10 000 ft = 0,0304 mm.
- On the projection 1 mil is a function of the distance D from the screen to the projector lens (that is to say the magnification ratio of the system) which is I = D:f, where f = projector focal distance, in this case 15 mm (D1-C projector). To obtain 10 mils, which are represented by 1 inch, on the screen is necessary to magnify of I = 1/0,304 inch will be

$$I = \frac{1''}{12''/1000} = \frac{1000}{12} = 83{,}33$$

With f = 15 mm the distance of the screen from the lens will be, in millimeter:

$$D = I \times f = \frac{1000}{12} \times$$

$$15 = \frac{15000}{12} = 1250 \text{ mm} = 49{,}2 \text{ in.}$$

6. PRACTICE FIRING

a. Scores and Pilot's Qualification

To qualify as a marksman the pilot must obtain the following results in practice firing:

EVENT	QUALIFICATION		
	STANDARD	GOOD	EXCELLENT
Air-to-air combat with two 30 mm guns			
Low angle strafing with two 30 mm guns			
High angle strafing with two 30 mm guns			
Air-to-air firing with two 12,7 mm machine guns	17%	26%	35%
Low angle strafing with two 12,7 mm machine guns	25%	37%	60%
High angle strafing with two 12,7 mm machine guns	35 ft	25 ft	15 ft
Rockets, 40° dive angle	35 ft	25 ft	15 ft
Rockets, low angle	65 ft	50 ft	35 ft
Skip bombing	50%	62,5%	75%
High angle bombing	115 ft	90 ft	60 ft
Low angle bombing (*)	125 ft	90 ft	60 ft

NOTE (*)

Generally not required

b. Penalties

Unless different local or general rules apply, lack of adherence to the established "minimums" is penalized as follows:

(1) Firing beyond the "foul line" during air to ground practice firing, or getting closer to the target than the minimum prescribed distance: penalty of 10% of accumulated score at first infraction. The second infraction causes the pilot to be immediately expelled from the range and the assignment of zero points.

(2) Firing at an angle of less than 15° in air to air firing. Rounds breaking more than 10 vertical strands are not considered as hits; rounds breaking more than 15 vertical strands result in zero points being assigned to the mission. Bullet holes in the last 5 feet of target A-6B may cause longitudinal tearings because of banner waving.
A judgment on whether an infraction was made or not can be given only by examining the assessing film.

(3) Firing from a distance of less than 600 ft in air-to-air firing (evaluation from the assessing film): 10% penalty the first time and zero points the second time.

7. REQUIREMENTS APPLICABLE TO QUALIFICATION MISSIONS

a. Air-to-Air Firing

(1) Firing with machine guns (90 rounds sharp in each weapon) or guns (60 guns sharp in each weapon)

(2) Carry out two missions scoring better than 17%

(3) Carry out no more than 8 firing passes per sortie

(4) The number of hits (plus the penalties, if any) divided by the number of rounds fired, multiplied by 100, will give the score, provided at least 75% rounds have been fired, and the remaining rounds are unfired because of weapon jamming.

b. Low Angle Strafing

(1) Firing with two machine guns with 90 rounds per weapon, or with two guns and 60 rounds per weapon.

(2) Accomplish three missions with a score better than 25%

(3) Fly no more than 8 firing passes per sortie

(4) The number of hits, minus the holes that are clearly a result of ricocheting undershoots, (with possible penalties), divided by the number of the fired rounds, multiplied by 100, will give the score.

If a jamming prevents firing of all rounds, the missions is considered valid only if at least 75% rounds have been fired.

c. High Angle Strafing

The same rules as for low angle strafing apply. Instead of the 1200 ft foul line, the minimum attained height is considered. It should however be higher than 1000 ft AGL.
The impact point is calculated at the first projectile impact.
The average of the errors of the single passes is considered as the mission mean error.

d. Low Angle Rocket Firing

(1) Two missions are required to qualify. A mean error of 65 ft or less is required in each mission.

(2) Four rockets in single are fired during each mission.

(3) Five passes maximum are allowed to fire the four rockets.

(4) The miminum altitude of 500 ft AGL must be complied with.

(5) If a rocket does not fire, the other three rockets are counted in the score, provided the passes are no more than five. If more than one rocket does not fire, the mission is not considered valid.
Firing error is evaluated from the ground. The average of the errors of the four (three) firings makes up the mission score.

e. Rockets, Medium Angle

The same general rules applicable to low angle rocket firing apply, except for the minimum altitude AGL, which must be 1000 ft.

f. Skip Bombing

(1) Two missions are required to qualify, a percentage higher than 50% must be scored in each mission.

(2) Four bombs in single are released per sortie.

(3) Five passes maximum are allowed to release the four bombs.

NOTE

If the aircraft is not configured to carry 4 bombs, two bombs can be released in single in a maximum of three passes.

(4) Minimum release altitude of 35 ft AGL and minimum release distance of 750 ft must be observed.

(5) If on a total number of four bombs, one bomb results in a hang-up, the score will be calculated basing on the three released bombs. If more than one bomb remains hung up, the mission is not valid. The maximum number of allowable passes remains five. In the case of missions carried out with two bombs, if one bomb results in a hang-up, the mission is not valid.

g. High Angle Bombing

(1) Two missions, each showing an average error of less than 115 ft are needed to qualify.

(2) Four bombs are released in single during each sortie.

(3) A maximum of five passes is required to release the four bombs.

NOTE

If the aircraft is not configures to carry four bombs, two bombs may be released in single in a maximum of three passes.

(4) The minimum release altitude of 1000 ft AGL must be complied with.

(5) If on four bombs, one bomb results in a hang-up, the score will be calculated on the three remaining bombs. If more than one bomb results in a hang-up, the mission is not valid. The maximum number of allowable passes remains however five. In case of missions carried out with two bombs, if one bomb results in a hang-up, the mission is not valid.

h. Low Angle Bombing

Usually pilots are not required to qualify as markmen in low angle bombing.
All rules applicable to high angle bombing apply, exception made for the average error which must be less than 125 ft and the minimum altitude AGL which must be 500 ft.

GLOSSARY

In this manual and in the associated manuals, you will find some words or expressions that are typical of the aeronautical environment, but that can be unfamiliar to people having a limited experience in this field. A brief list of this terms is given hereafter with a short explanation.

DEFINITIONS

A

ADVERSE YAW

A yaw opposite to the direction of turn, induced by rolling motion and aileron deflection. The yaw moment greatest at high lift conditions and full aileron deflections.

AGILITY (of an aircraft)

This is the ability to promptly respond to accelerations applied along and about the aircraft axes.

AIMPOINT

The preplanned point near or on the target that is used to align the pipper. Usually this is a point that is offset from the target to correct for the wind effect.

AIRCRAFT AXES

There are three axes which are mutually perpendicular and have a common point of intersection:

a. Longitudinal Axis: This axis is parallel to the fuselage reference line. Rotating the longitudinal axis will change the aircraft angle of attack and/or pitch.

b. Vertical Axis: This axis is perpendicular to the longitudinal axis. The aircraft rotates about this axis when yawing.

c. Lateral Axis: This axis rotates about the longitudinal axis when the aircraft is rolled or banked.

ALTITUDE LOST

This is the altitude lost during a pullup subsequent to a dive or fast descent

ANGLE OF ATTACK

The angle between the fuselage reference line and the relative wind.

ANGLE OF GUNFIRE (AGF)

The angle between the fixed bore line and flight path.

ANGLE OF INCIDENCE

This is the angle of wing setting or stabilizer setting. It represents the acute angle between the longitudinal axis of an airplane and the chord of

	the wing at root or the chord of the stabilizer, as applicable, looked at from the side. This term is never used in the manual, but is listed herein to highlight that it does not define the same feature as the angle of attack (AOA)
ANGLE OF PITCH	The angle of the aircraft flight path relative to a level plane.
ANGLE-OFF	The angular measurement between line of flight of an aerial target and flight path of the attacking aircraft.
APP	Approach (control) - Air traffic control activity controlling approach and take-off in IFR
APPARENT VERTICAL	The direction of the resultant of the inertia forces applied to the aircraft.
	B
BASE LEG	A segment of a landing pattern followed by an aircraft just prior to the final approach (see FINAL) and after the downwind leg. It is a 180° descending turn flown at decreasing speed. Flaps are in landing position
BREAK AWAY	To peel off from a formation to subsequently rejoin in extended trail
BREAK AWAY TO LAND	This maneuver is flown along the landing pattern at pre-established altitude and airspeed. It consists of a 180° turn that all aircraft in the formation play in 1 to 4 sec intervals. The leader breaks over the runway threshold (or 50 m on the side)
BREAK, BREAK-OFF	Brisk escape maneuver, break of formation, direction to break formation
BRIEFING	A brief verbal explanation of something, or more precisely, the instruction or lecture given to aircrew or air passengers before the flight regarding procedures to be followed, route, weather conditions, mission requirements, radio procedures, safety of flight, air traffic limitations and operational limitations.
BOMB TRAJECTORY	The path of a bomb from release to detonation. The trajectory is the result of bomb ballistics, release velocity, release angle, and release height above burst

BULLET DENSITY	Number of rounds passing through an area of 1 square foot for unit of time
BULLET DISPERSION	Deviation of a bullet trajectory from the aiming point
BULL'S EYE	The center dot of the practice target. It is a red circle usually having a 2 ft dia.

C

CLOSED PATTERN	A landing pattern which is flown in simulated or actual fuel low conditions to go to landing in the shortest possible time
CONTROLLABILITY	The quality in an aircraft that provides for effectiveness and ease of control
CORRECTED SIGHT DEPRESSION	True sight depression corrected for a head or tailwind component
CRABBING	Literally: to move like a crab. To turn an aircraft partly into the wind to compensate for drift.
CREW CHIEF	The flight line specialist responsible for pre and post-flight inspections and for servicing.
CROSS-CHECK	A type of check. It refers essentially to the observation and interpretation of the navigation instruments that are complementary to one another. The indications of one instrument confirm, or do not confirm, the indications of the others.
CRUISE (cruising flight)	Stabilized flight at constant altitude and airspeed, with landing gear, flaps and speedbrake in.

D

DEBRIEFING	Short verbal report the pilot or the formation leader offers to the operational and technical personnel after return from a mission. Short comment/report that the formation leader or the instructor offers to the pilots immediately after flight.
DOWNWIND	The leg of the landing pattern during which the aircraft flies downwind, with heading at 180° with respect to that of the runway in use. This leg is flown at constant altitude.

E

EFFECTIVE SIGHT DEPRESSION — The amount of depression represented by the angle formed by the flight path and the depressed sight line. This angle varies as flight conditions very; however, the angle formed by the true zero prediction sight line and the depressed sight line will remain a costant. Effective and required sight depression will be the same when pre-planned flight conditions are met.

ELEMENT — A pair of aircraft in a four-ship formation

EQUIVALENT AIRSPEED — Calibrated airspeed, i.e. airspeed corrected for instrument errors, further corrected for compressibility at altitudes different from MSL.

ESTIMATED — Radio terminology. It usually indicates the time (generally minutes only) at which overflying of a given point is assumed to take place.

F

FERRY — Aircraft configuration including external fuel tanks and excluding external armament stores.
It also means ferry flight.

FINAL — The last leg of a landing pattern, during which the aircraft is lined up with the runway and is held to a fairly constant speed and rate of descent.
It is followed by touch down

FIRING RANGE — It has two meanings:

a. A site designated for air to surface firing practice,

b. The range or distance from a target at which a gun can be fired with effective results, as in "he was within firing range", this range considered as a capability of the gun.

FLIGHT — A formation of four aircraft, irrespective of type

FLIGHT LEVEL — Barometric altitude of an aircraft in hundreds of feet, with respect to the standard barometric level of 1013.15 mb (acronym is FL).

FOUL LINE	In aerial gunnery practice, a line on the ground in front of the target beyond which guns are not to be fired. Rounds fired beyond this line are not included in the score.
FULL STOP LANDING	Radio call indicating that the flight will terminate after landing. After landing, the aircraft goes to parking
FIX	A point instrumentally detected or calculated, that is overflown by the aircraft. If the overflown point is checked visually, it is called PIN POINT.
FLYING QUALITIES	The measurement of the motion of the aircraft CG (speed, climb, etc.).
	G
GO-AROUND	Maneuver played during final approach or on base turn. It consists of engine reopening to 100% RPM, retraction of the landing gear and flaps, and gain of altitude to enter the traffic pattern again.
GROUND	The air traffic control activity controlling the movements of the aircraft on the ground through the radio on applicable frequencies
	H
HOLD	To hold a position
	I
IDLE	Engine at minimum power. Engine throttle fully back. Idle RPM
INITIAL	"Initial Point" for the subsequent break maneuver. This point must be overflown at given IAS and altitude AGL. It is normally located 2 NM ahead of the threshold of the runway in use along the approach path.
	K
KNOT	Speed equivalent to 1 nautical mile per hour = 1,852 km/h

L

LANDING CONFIGURATION	Aircraft with landing gear and flaps down

M

MANEUVERABILITY (of an aircraft)	The quality in an airplane which permits the pilot to change its direction or attitude with minimum effort
MOBILE RUNWAY CONTROL	The radio station located in proximity of the threshold of the runway in use. It provides for monitoring of all pre-take-off and final approach maneuvers and calls when required on the applicable frequencies to give directions or recommendations to enforce discipline and for the sake of safety.

N

NATO-AIR-STD	Nato Air Standard
NATO STANAG	Standard agreement (among the NATO countries)
NOW	The radio call of the leader directing the performance of a maneuver that had been explained at an earlier time

P

PENETRATION	Fast descent from high altitude at reduced power and high or medium airspeed. It requires that the speedbrake be used.
PERCH	Position in the air-to-air firing range taken by the attacking aircraft before starting the firing pass. It is higher than and on the side of the target and slightly aft of it.
PERFORMANCE	The measurement of the aircraft CG motion
PICKLE	Push-button for bomb release and rocket firing.
PIN POINT	Positively overflown and visually checked point.
PIPPER	Center point of the gunsight lighted reticle
PREDICTION ANGLE	It refers to a gyro aiming system. It is the vector sum of the lead angle, trajectory shift correction, gravity drop correction and (sometimes) the relative air density correction.

PULL-UP	The resulting maneuver after the pilot pulls the stick aft sharply
PULL-UP POINT	The point at which a quick and sharp climb is established after attack
	R
RAM AIR SCOOP	A ram air intake. In the MB-339A this intake is used for forced cabin ventilation
	S
SAFE ESCAPE	Altitude above the ground assuring that the aircraft will not be hit by the debris of the bomb or rocket it has released or fired.
SLANT RANGE	The line of sight range between the aircraft and the target at the instant in which the weapon is released.
STEER	The steering system. When it is engaged, the nosewheel is controlled by the rudder pedals.
STRAFE	Live pass with guns or machine guns against a surface target
	T
TOP	The highest point in a maneuver in which altitude changes are performed
TO TRIM	To aerodynamically balance the aircraft by means of the trims
TOUCH AND GO	Landing immediately followed by engine reopening and take-off.
TOWER	Air traffic control activity. It operates from a facility, usually a tower, located in a center position in the airfield area. It channels the VFR air traffic on the airport and in its vicinity up to an established altitude (generally 5000 ft) by giving directions
TUGRIT SERVICE	Air navigation assistance service provided by the Air Defence Services of Turkey, Greece and Italy

V

VELOCITY JUMP

It has the same meaning as "trajectory shift". This is the deviation of the trajectory of a projectile due to the kinematic composition of the motions of the projectile and the aircraft when the barrel axis is not aligned with the flight path.
It is the angle, measured in milliradians, of the deviation of the bullet trajectory when it leaves the barrel. Generally, "velocity jump" defines the deviation in the plane of symmetry of the aircraft (or on a plane parallel to it), while "trajectory shift" defines the deviation normal to this plane and due to the convergence of the weapons.

W

WILCO

Short for I WILL COMPLY.
This word should be used when appropriate in lieu of the more generic OKAY or ROGER.

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ACRONYMS AND ABBREVIATIONS

	A
A/A	Air to Air
ADF	Automatic Direction Finder
ADI	Attitude Direction Indicator
ADL	Armament Datum Line
A/G	Air to Ground
AGL	Above Ground Level
AHRS	Attitude Heading Reference System
AOA	Angle of Attack
APP	Approach
ARO	Airdrome Reporting Office
ATA	Actual Time of Arrival
ATC	Air Trafic Control
ATD	Actual Time of Departure
ATO	Actual Time Over
ATS	Air Transfer Service
	B
BCN	Beacon
BIT	Built In Test
BRD	Bomb Rocket Dispenser
BRG	Bearing
BRT	Bright
	C
CAS	Calibrated Air Speed
	D
DG	Directional Gyro
DISP	Dispenser
DIST	Distance

DME	Distance Measuring Equipment
DR	Dead Reckoning

E

EAS	Equivalent Air Speed
EBL	Effective Bore Line
EMER, EMERG, EMG	Emergency
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
ETO	Estimated Time Over

F

FBL	Fixed Bore Line
F/D	Flight Director
FDS	Flight Director System
FIC	Flight Information Centre
FIR	Flight Information Region
FGL	Fixed Gun Line
FL	Flight Level
FLIP	Flight Information Publication
FLT	Flight
FM	Flight Manual
FRL	Fuselage Reference Line
FWD	Forward

G

G,g	Gravitiy
GCA	Ground Controlled Approach
GCI	Ground Controlled Interception
GND	Ground
GS	Ground Speed

H

HA	High Altitude (from 25 000 to 40 000 ft)
HAB	High Angle Bombing
HAS	High Angle Strafing
HDG	Heading
HI	High
HSI	Horizontal Situation Indicator
HVHA	High and Very High Altitude

K

KCAS	Knots Calibrated Air Speed
KEAS	Knots Equivalent Air Speed
KIAS	Knots Indicated Air Speed
KTAS	Knots True Air Speed
KT	Knots

I

IAF	Initial Approach Fix
IAS	Indicated Air Speed
IFF	Identification Friend/Foe
IFR	Instrument Flight Rules
IGN	Ignition
ILS	Instrument Landing System
IMC	Instrument Meteorological Condition
IMN	Indicated Mach Number
IP	Initial Point
ISA	International Standard Atmosphere
ITO	Instrument Take-off

J

JPT	Jet Pipe Temperature

L

L	Lift
L1	Light 1 (on Gunsight Control Panel)
L2	Light 2 (on Gunsight Control Panel)
LA	Low Altitude (from 1000 to 5000 ft)
LAB	Low Angle Bombing
LARF	Low Angle Rocket Firing
LAS	Low Angle Strafing
LAT	Latitude
LDGP	Low Drag General Purpose (Bombs)
L.G.	Landing Gear
LH	Left Hand
LL	Launcher Line
LO	Low
LOC	Omni-directional Localizer
LOD	Line of Departure

M

M	Mass
MAN	Manual
MAX, max	Maximum
MFBL	Mean Fixed Bore Line
MIN, min	Minimum
MOBILE	Mobile Control Post
MSL	Mean Sea Level
MSTR	Master

N

NAV	Navigation
NDB	Non Directional Beacon
NM	Nautical Miles

N & T	Nose & Tail - Bombs Fuzes (Armament Control Panel)
No.	Number
NOR, NORM	Normal
NW	Nosewheel

O

OAT	Outside Air Temperature
OXY	Oxygen

P

PARK	Parking
PRE	Preselection
PUP	Pull-Up Point
PWR	Power
PYL	Pylon (tanks)

Q

QTY	Quantity

R

R	Right
RH	Right Hand
RKT	Rocket
RMA	Rockets Medium Angle
RNAV	Area Navigation
RPM, rpm	Revolutions per Minute
RX	Rocketry

S

SB	Skip Bombing
SEC	Secondary
SEL	Selector/Selected
SGL	Single

SIF	Selective Identification Feature
SL	Sight Line
SOP	Standing Operational Procedure
SPD	Speed/Speed (brake)
SQL	Squelch
SR	Slant Range
STBY	Standby
SW	Switch

T

T	Traction - Thrust
T/O, T.O.	Takeoff
T/R	Transmitter/Receiver
TAS	True Air Speed
TK	Tank
TIP	Fuel Tip Tank
TMA	Terminal Area
TOT	Total
TOT	Time Over Target
TWR	Tower

U

UHF	Ultra High Frequency

V

VAR	Variation
VASIS	Visual Approach Slope Indicator System
VFR	Visual Flight Rules
VHA	Very High Altitude (above 40 000 ft)
VHF	Very High Frequency
VLA	Very Low Altitude (below 1000 ft)
VMC	Visual Meteorological Condition

VOL	Volume
VOR	Very High Frequency Omni-directional Radio Beacon
VV	Vertical Velocity

W

W	Weight
W	West
WD	Wind
WILCO	I Will Comply
WPT	Waypoint